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AVOCADO THRIPS BIOLOGY AND CONTROL

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Historical Review

The major thrips pest attacking avocados in California is the avocado thrips, *Scirtothrips perseae* Nakahara. This insect was first noticed in California in July 1996 when it was discovered damaging fruit in a Saticoy avocado orchard in Ventura County. Avocado thrips was also found at approximately the same time at Irvine in Orange County. Following these initial discoveries, avocado thrips populations increased rapidly, causing significant damage to foliage and fruit. In little under a year, avocado thrips spread north and south of Ventura and was found in San Diego County in May 1997. By July 1997, significant damage attributable to avocado thrips feeding was noticed in orchards in San Diego County. By May 1999, areas infested with avocado thrips had stabilized and 99% of California avocado acreage is now infested to some degree with this pest. Avocado thrips management costs have reduced industry revenues by 12%, increased production costs by 4.5%, and economic models indicate long-term losses to the California avocado industry to be around $4.45-$8.51 million per year (Hoddle et al., 2003). Costs to the California avocado industry related to avocado thrips management will vary year-to-year depending on pest severity and fruit value.

California Avocado Commission

Fruit scarring of 'Hass' by avocado thrips can be severe, resulting in "alligator skin" and serious economic damage. Long-term losses to the California industry caused by avocado thrips are estimated to be around $4.5-$8.5 million per year (Hoddle et al., 2003).

Area of Origin for Avocado Thrips

In 1971, a quarantine interception at the Port of San Diego resulted in the collection of a single female specimen of an undescribed species of *Scirtothrips* on avocados from Oaxaca in southern Mexico. This single specimen is very similar in appearance to avocado thrips found in California. Adult *S. perseae* may occasionally be found resting on non-avocado plants in heavily infested avocado orchards. Avocados are native to Central America, and humans have moved plants out of this region into South America, the Caribbean, and elsewhere. Foreign exploration efforts for avocado thrips and its natural enemies in the native range of avocados have shown that *S. perseae* has a narrow geographic distribution, and is found throughout the avocado growing region between Michoacan in Mexico and central Guatemala. Avocado thrips has not been found on avocados in Costa Rica, the Dominican Republic, Trinidad, Brazil, or Chile.

Avocado thrips,
Scirtothrips perseae

Identification

Avocado thrips larvae and adults are found primarily on the undersides of immature leaves and fruit. First instar larvae are pale white-yellow, while second instar larvae are much larger and bright yellow in color. Adult avocado thrips are straw yellow in color, the abdomens may appear greenish because of the chlorophyll extracted from plant material during feeding. The adults also have three bright red dots, or ocelli, between their eyes, which are light sensitive organs. Avocado thrips are readily distinguishable from another pest thrips in avocados, the greenhouse thrips, which are much larger and black in color. Western flower thrips, a common native Californian thrips species, is yellowish-brown in color and is about 33% larger than avocado thrips. It is never found feeding on leaves and fruit, but is often found in avocado flowers feeding on pollen. Adult western flower thrips can be distinguished from adult avocado thrips based on size, obvious bristles on the tip of the abdomen which avocado thrips lack, and their association with avocado flowers.

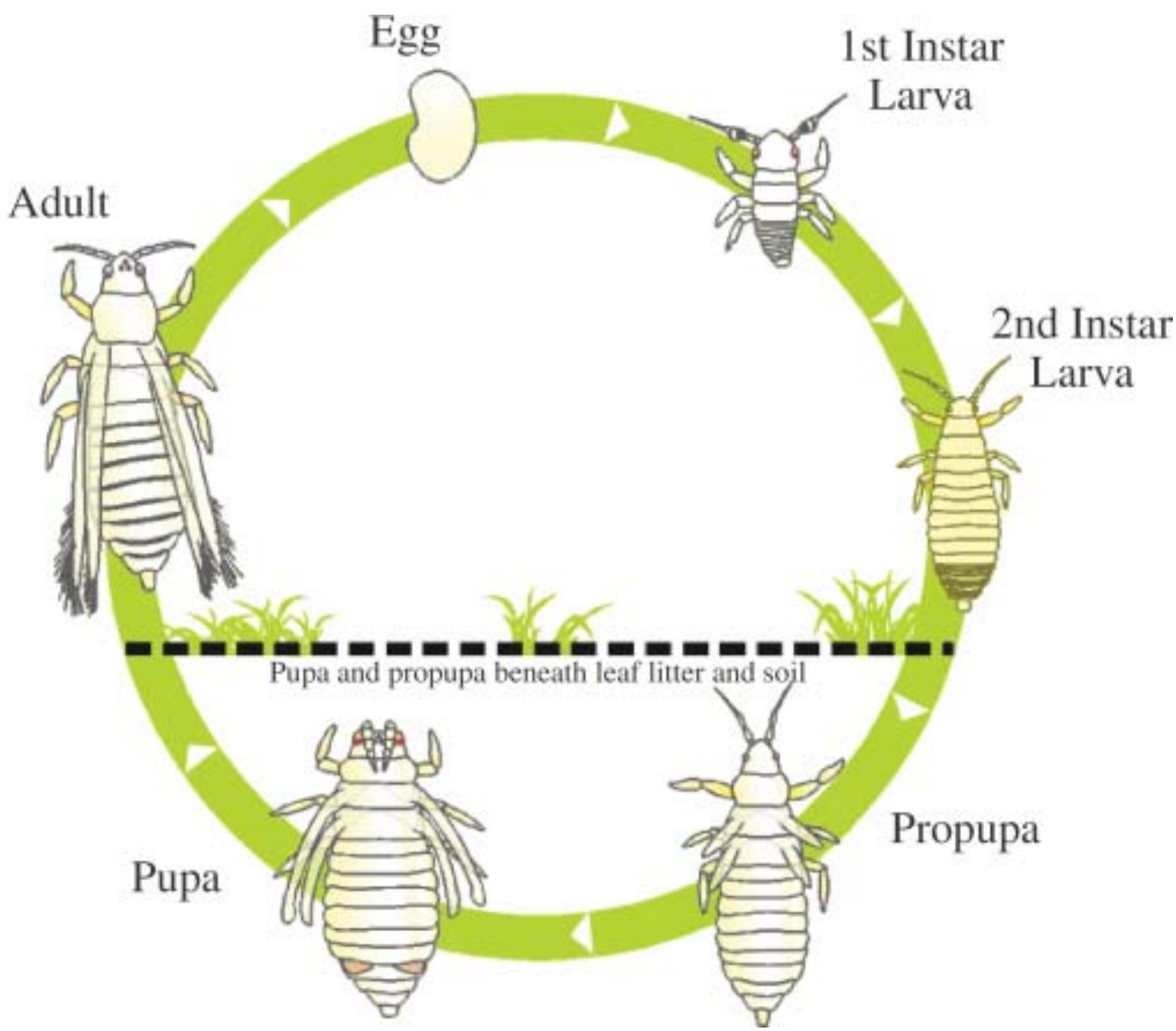
Field Ecology

Avocado thrips larvae and adults can build to high densities over the fall through spring period on young leaves. When severe thrips feeding damage occurs, it can cause premature leaf drop. The main source of economic loss attributable to avocado thrips, however, is scarring of immature fruit in spring by larval and adult thrips feeding activity. Scarring can be severe enough to render the entire fruit surface brown, and a characteristic “alligator skin” appearance results. Fruit that are entirely scarred can continue to size although these are often smaller than normal, while the flesh remains healthy and green. Elongate scarring results when avocado thrips feeding damage to young fruit elongates as fruit matures. A grower survey analysis indicated that orchards within 10 miles of the coast typically have a more severe avocado thrips problem than orchards further inland. The cool marine influence is thought to be conducive to avocado thrips population growth, while the hotter interior regions are too harsh for avocado thrips. Consequently avocado thrips densities decline in the field with the onset of hot summer weather, even when there is abundant foliage available for feeding and oviposition. Mean weekly maximum temperatures that exceed 86°F can cause a decline in avocado thrips larvae and adults on young leaves. The influence of high temperatures on populations in orchards is not immediate. It appears that high daily temperatures (i.e. maximum daily temperature must exceed 86°F) and possibly low canopy humidities are needed for several consecutive days to cause avocado thrips population declines. Thrips populations steadily recover when mean weekly maximum temperatures decrease and are within the range 68-76°F, if there is abundant foliage for feeding and oviposition, and if natural enemy activity is low.

Avocado Thrips

(*Scirtothrips perseae* Nakahara [Thysanoptera: Thripidae])

Life Cycle



Biology of Avocado Thrips

Avocado thrips has six distinct life stages. Females lay eggs inside young leaves and fruit. Two larval stages subsequently develop and feed on young leaves and fruit. The two pupal stages are non-feeding and pupation occurs either in cracks or crevices on branches or in leaf duff below trees. Adults, which emerge from the pupal stage, feed on leaves and fruit, and because they can fly, can disperse to adjacent trees to search for young leaves and fruit in which to lay eggs.

Laboratory studies have indicated that avocado thrips larvae and adults exhibit highest survivorship, longevity, and fecundity at moderately cool temperatures (68-76°F). Moderately hot temperatures (86°F), cause high larval mortality and reduced adult longevity when thrips are confined in small cages under constant laboratory conditions (Table 1).

Preferences for low temperatures may optimally coordinate avocado thrips development and reproduction with avocado phenology over the spring when plants are producing young leaves and fruit, which are ideally suitable for thrips feeding and oviposition.

Table 1. Mean developmental times in days, mean total number of eggs laid by females until death (fecundity), and proportion of offspring (sex ratio) that are female for avocado thrips at five constant temperatures in the laboratory.

	TEMPERATURE				
Life Stage	**59°F (15°C)**	**68°F (20°C)**	**77°F (25°C)**	**81°F (27°C)**	**86°F (30°C)**
EGGS	21	14	11	10	9
1st INSTARS	4	3	2	1.5	1.8
2nd INSTARS	7	4	3	2	2
PROPUPAE	3	2	1.3	1.1	1.4
PUPAE	7.5	4	2.5	2.4	2.5
ADULTS	40	14	8	7.5	3
FECUNDITY	40	31	20	21	-
SEX RATIO	0.63	0.69	0.62	0.15	-

Avocado Thrips and Fruit Scarring

Female avocado thrips will oviposit into young fruit and feeding by emerged larvae can damage fruit, depending on the number of thrips present and how long they feed. Observation of field-collected ‘Hass’ fruit in the laboratory indicates that females will lay eggs in fruit ranging from 0.16-3.0 inches in length. The majority of larvae (>95%) will emerge from fruit 0.59-2.5 inches in length, with the highest numbers emerging from fruit 1.5-1.7 inches in length. Observations in the field on ‘Hass’ indicate that fruit 0.8-1.6 inches are most preferred by avocado thrips, possibly because fruit of this size have a reduced propensity to drop prematurely from trees and they are still tender enough for oviposition and larval feeding. Once fruit exceeds 2 inches in length, avocado thrips adults and larvae are found primarily on young leaves. In the field, fruit are most susceptible to damage when fruit are 0.2-0.6 inches in length. Based on a ‘Hass’ study in Ventura County, when approximately 3-5 thrips are consistently found per leaf 97 days, 75-36 days before fruit set, and during fruit set, feeding will cause 26-38%, 18-28%, and 6-15% economic scarring damage on fruit, respectively.

Female avocado thrips will lay eggs into young fruit and leaves. Feeding by emerged larvae can cause economic damage to fruit, depending on the number of thrips present and how long they feed.

Sampling for Avocado Thrips

The most effective way to sample for avocado thrips larvae and adults is to use magnifying equipment to examine the undersides of leaves for the presence of thrips. Small fruit can be examined in a similar manner. Avocado thrips are highly attracted to yellow sticky cards. Sticky cards can be a very useful tool for monitoring adult densities in orchards over time, gauging directionality of flights within orchards, and for monitoring natural enemy species and their relative densities. Sticky cards should only be used for avocado thrips monitoring if the scout examining the cards is expert enough to separate avocado thrips from other yellow-colored thrips species that are also likely to be caught on the cards. It is advisable to have a qualified pest control advisor (PCA) monitor your thrips populations before and during periods of potential fruit damage.

Biological Control of Avocado Thrips

Several species of predacious insects eat avocado thrips in California avocado orchards. These natural enemies include green lacewing larvae, a predaceous thrips, *Franklinothrips orizabensis*, and predatory mites, in particular *Euseius hibisci*. Minute pirate bugs have not been recorded attacking avocado thrips. In a small-scale field trial in Fallbrook, releasing green lacewing larvae onto top-worked trees 10 ft. in height with 12 avocado thrips larvae/leaf at a low (325 lacewing larvae/tree) and high release rate (5,045 lacewing larvae/tree) did not provide significant control of avocado thrips (Silvers, 2000). Lacewing larvae were used augmentatively in this trial and adequate thrips control over a six-week period may have been an unrealistic expectation. An alternative approach could be to use lacewing larvae inoculatively. With this approach, natural enemies might be released early in the season and allowed to increase in density in response to increasing avocado thrips numbers. However, the efficacy of inoculative lacewing releases when avocado thrips densities are low has yet to be verified experimentally.

In an initial experiment, two releases of *Franklinothrips* at 218 adults per tree failed to control avocado thrips at densities of 12 larvae/leaf. In this study, a major problem identified was the poor quality of the predator after shipping from Europe to California. After transit > 50% of adults had died and survivors were probably of marginal health. In two later studies, weekly releases of *Franklinothrips* at a rate of approximately 50 adults per tree failed to control avocado thrips at initially low (1 thrips per leaf) and high densities (25 thrips per leaf) at sites in Escondido and Ventura, respectively. In these studies, a major problem was a lack of consistent thrips populations at densities that could support predator population growth – the low-density populations did not develop and the high-density populations crashed soon after the trial started. Further research is needed, but at present we cannot verify effective control of avocado thrips field populations with either lacewing or *Franklinothrips* releases.


An adult female, *Franklinothrips* n. sp.


A larval, *Franklinothrips* n. sp.

Laboratory work on *Franklinothrips* has identified the optimal temperatures, diets, harvesting of pupae, and automated sorting of pupae, techniques that are applicable to cost-effective mass rearing this predator. Adult *Franklinothrips* females can eat approximately 14-20 second instar avocado thrips larvae in a 24-hr. period. This predator does not show a feeding preference for first or second instar avocado thrips larvae. Both life stages are equally likely to be attacked after the predator encounters them. *Franklinothrips* spend around 2-5% of their time probing avocado leaves with their mouthparts. This observation may explain, in part, why *Franklinothrips* populations decline following applications of insecticides that exhibit translaminar activity (Agri-Mek and Success). Leaf feeding in this manner may expose *Franklinothrips* to insecticides that have moved into leaf material, thereby killing them.


A predatory green lacewing larva

Foreign exploration for avocado thrips natural enemies (predator thrips and parasitoids) in Mexico is ongoing. A thrips parasitoid, *Goetheana incerta*, a natural enemy of South African citrus thrips, *Scirtothrips aurantii*, is being studied in quarantine at UC Riverside. Rearing and evaluation work with *G. incerta* against avocado thrips in quarantine is in progress.


The predatory mite, *Euseius hibisci*


A minute pirate bug, *Orius* sp.

Cultural Control of Avocado Thrips

A novel method of controlling avocado thrips pupating in the soil beneath host trees (around 78% of second instar larvae drop from trees to pupate in the soil) using coarse composted organic yard waste is presently under evaluation. This mulch is available from reputable green waste processing facilities and freshly, well-composted material is devoid of avocado pests and diseases when it is delivered. A small field trial demonstrated that 50% fewer thrips larvae emerged from mulch laid under avocado trees in comparison to non-mulched trees that had normal leaf duff and branches under them. We speculate that mulch suppresses avocado thrips pupation because it harbors a more diverse fauna of natural enemies (including insect killing fungi, nematodes, and generalist arthropod predators) that opportunistically feed on micro-arthropods living in the mulch. This diverse fauna is somewhat lacking in avocado leaf duff. Consequently, these generalist natural enemies attack avocado thrips larvae that fall from trees to pupate. Interestingly, about 98% of *Franklinothrips* larvae drop from trees to pupate in the soil. Organisms living in the mulch do not adversely affect *Franklinothrips*, probably because they pupate within protective silk cocoons, something avocado thrips does not do. It is unknown if mulch can provide orchard-wide suppression of avocado thrips, if reduction of thrips emergence is great enough to prevent economic damage to fruit, if the level of suppression seen is consistent year to year, or how regularly mulch needs to be reapplied as it decomposes. This study requires replication in different orchards for longer time periods to address these unanswered questions before we can recommend mulches for avocado thrips control. Previous studies have shown that mulches of this type also provide significant avocado root rot control (Downer et al., 1999).

Chemical Management of Avocado Thrips

In developing a strategy for managing avocado thrips, a grower should consider a large number of interrelated factors including tree size and vigor (which may affect the amount and timing of leaf flushes which avocado thrips prefer), the past history of avocado thrips population dynamics and fruit scarring experienced in the grove and surrounding regions, the amount of leaf flush and/or small fruit present, whether these fruit are the major "set" or additional fruit sets are expected, avocado thrips levels, natural enemy levels, grove topography, spray equipment availability, and the grower's tolerance for fruit scarring and interest in preserving avocado thrips pesticide susceptibility. One should also consider that the weather and the timing and amount of leaf flushes and avocado fruit sets can vary tremendously from year to year. Just because avocado thrips caused significant fruit scarring one year, or in a particular grove, does not mean that this or other nearby groves will have economic avocado thrips levels in subsequent years. Many groves do not need to be treated for avocado thrips control and as a general principle, if practical (see comments on spray equipment availability below), it is best to withhold treatments as long as possible to maximize the negative impact of weather and natural enemies on avocado thrips levels. Under ideal circumstances and if practical, treatments should not be applied until it is clear that economic levels of avocado thrips are present during significant fruit set and are likely to cause economically significant damage (i.e. one might withhold treatments on off-bloom fruit, if hot weather is imminent, if natural enemy levels are high, or if one has a high tolerance for fruit scarring).

Because making decisions on the need for and timing of avocado thrips treatments can be difficult, we suggest that the grower become as familiar as possible with avocado thrips and natural enemy biology, possible control options, and/or employ a knowledgeable pest control advisor to assist with scouting and decision-making. It would be nice if simple decision rules were available, but the reality is that each year and grove situation can be different and it is only through experience that one develops the ability to make optimal pest management decisions.

There are three major options for avocado thrips chemical control as listed below (read and follow the pesticide label for restrictions, warnings and recommended rates; in particular note label restrictions on the use of Success and Agri-Mek during bloom when bees are foraging). Materials are listed from least to most persistent control of avocado thrips.

With all three available insecticides for avocado thrips control, the development of avocado thrips resistance is a real concern and unnecessary treatments should be avoided.

1. *Veratran D + Sugar/Molasses*
   This material is a botanical pesticide made from the ground seeds of a lily-like plant, *Schoenocaulon officinale* (Morse, 1998a). A 50-lb. bag of Veratran D contains 80% (40 lbs.) sugar as a bait and 0.2% sabadilla alkaloids (0.1 lbs. or 45.4 grams). Up to an additional 10 lbs. sugar or 1.5 gallons molasses should be added to the spray mix. The liquid in the spray tank should be acidified to pH 4.5 prior to adding the Veratran D to the tank. Acidification helps to maximize treatment efficacy. Veratran D residues are not persistent on leaves and are reduced to 50% of the initial level approximately 4 days after treatment (Hare and Morse, 1997), resulting in perhaps 1-3 weeks of control depending on weather, application method, and thrips levels. (Since it is a bait, rain will tend to wash off the material and can render treatment ineffective). To avoid plugging of spray lines, screen size should be 20 mesh or larger and, because this material must be consumed by the thrips to be effective (it is a stomach poison with minimal contact activity), it is wise to withhold additives from a Veratran D treatment unless experience has shown that efficacy is not compromised. Because Veratran D is a stomach poison, it is relatively innocuous to most natural enemies. In a grove in Ventura County with 6 Veratran D treatments over 2 years, an 11-fold resistance of avocado thrips developed to this material.

2. *Success 2 SC + Narrow Range 415 Spray Oil*
   Success is in the macrocyclic lactone class of chemistry, is unstable in sunlight (most surface residues are degraded within a day), and exhibits translaminar activity (it moves into the upper cell layers of leaves or fruit where it is toxic to avocado thrips when they feed). Oil is required to move Success into leaves or fruit and should be added to the spray tank at a rate of .25-1%. Do not use acidifying buffering agents in tank mixes with Success. Success is relatively innocuous to natural enemies and treatments normally hold for 2-4 weeks.

3. *Agri-Mek 0.15 EC + Narrow Range 415 Spray Oil*
   Agri-Mek is also a macrocylic lactone, is unstable in sunlight, exhibits translaminar activity, and must be used with oil. Thrips poisoned by Agri-Mek take 3-5 days to die and, thus, control can be somewhat slower than with faster acting insecticides. This material is quite persistent in leaves and treatments and can hold for 6-10 weeks or more. Agri-Mek is also fairly innocuous to natural enemies. At the time this went to print, this material may be applied under a Section 18 Emergency Use Authorization.

Avocado Thrips Resistance Potential

We have already seen avocado thrips develop resistance to Veratran D at two field sites in Ventura County. If Veratran D is being relied on for avocado thrips control, we suggest a maximum of 2-3 applications per year. Additionally, this material should be rotated with either Agri-Mek or Success to reduce the rate at which insecticide resistance can develop. Avocado thrips also have the potential to develop resistance to Agri-Mek and Success. Because Agri-Mek and Success are of similar chemistry, there is a concern that cross-resistance might appear (i.e., if thrips develop resistance to one material, they might become resistant to the other). For these reasons, we suggest that growers apply only a single treatment of Agri-Mek per year up to a maximum of two applications of Success per year (it is less persistent in leaves and fruit than is Agri-Mek), or up to a total of one Agri-Mek and one Success treatment per year.

Spray Application Methods

Most avocado groves are on hillsides, making it difficult to apply pesticides other than by air. A problem, however, is that there are a limited number of companies that provide air treatments to avocados; thus, in years when the weather is warm and thrips levels are high, one can be caught in a spray queue. Even if treatment recommendations are written early, application may not occur until after appreciable scarring has occurred on fruit. For this reason, we suggest that growers consider the possibility of applying treatments using ground spray equipment. We have experimented with a small hand-gun sprayer which can be pulled behind a truck or ATV. One can usually access most avocado groves via harvest drive rows and, if necessary, a 100-foot hose can be used to access trees several rows away from the drive row. The advantage of such equipment is that sprays can be timed optimally and coverage can be good from the ground (unless trees are extremely large, in which case growers might consider topping the trees). In regions where avocado thrips is a recurring problem, we suggest that growers in an area might consider pooling their resources to build or purchase hand-spray equipment, or consider contracting out to companies who might apply such treatments. For long-term resistance management, it would be best to apply a single treatment shortly before thrips start scarring fruit (i.e., during late bloom if possible) using ground application and thorough spray coverage.

Considering the Use of Prebloom Sprays

Because of spray queue concerns, especially in regions where applications during bloom or in the presence of honey bees are restricted, some growers have experimented with prebloom Agri-Mek sprays (Veratran D and Success are normally not sufficiently persistent to provide fruit set control when applied during the prebloom period). If high avocado thrips populations (perhaps 5 immature thrips per leaf or more) are present on foliage in San Diego County prior to bloom, and one does not have the option of using a ground spray, then such a strategy may be justified. A concern, however, is that avocado thrips populations often decline during the bloom period (depending to a good extent on the amount of tender leaf flush available) and often such prebloom treatments may not be needed. We certainly want to avoid applying two treatments of Agri-Mek (one prebloom and then a second after bloom during the ensuing leaf flush). This is an additional reason why growers might consider the feasibility and economics of ground sprays. The timing of flowering and new leaf growth may vary from year to year, along with thrips populations. It is therefore highly advisable to get professional assistance from a qualified pest control advisor when making prebloom spray decisions.

We are testing new chemicals for avocado thrips control but, at present, few alternatives to the materials we currently have appear promising. All three of the materials we presently have available for avocado thrips control are quite selective (minimal impact on natural enemies and lack of disruption of other pest species). In addition, Agri-Mek provides remarkably persistent avocado thrips control. This, however, is a double-edged sword – control persistence is a plus but this persistence also contributes to the potential for resistance developing more quickly than if the material were less persistent. We cannot emphasize enough that growers and pest control advisors should consider pesticide resistance management when planning their avocado thrips management program.

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