Avocado Thrips Subproject 2:
Agri-Mek and Success Evaluations and Phenology in the Field

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Benefits to the Industry

The benefits of this research to the avocado industry are direct and are expected to be long lasting because it provides information that will help control avocado thrips, the most serious threat to avocado production in southern California in recent years and a pest that appears to be here permanently. In this project, we have determined the best spray volumes to apply by helicopter when using Veratran D (sabadilla) and Agri-Mek (abamectin) to control avocado thrips. This greatly benefits the industry because this will reduce costs to the grower; high spray volumes are more expensive to apply than low volumes, so applying the lowest volume that will result in effective control is the best option. We have also determined the efficacy of a new material registered for use on avocado. In March 2000, Success (spinosad) was fully registered for use against avocado thrips. However, this was made before any efficacy data with this material using helicopters were gathered. Because helicopter application is the major method of applying insecticides against avocado thrips in many areas of southern California, we carried out important trials to determine the material's efficacy compared with that of Agri-Mek. Results from this research will greatly benefit the industry by providing information on how the two insecticides may be used together in a control program. We have also determined the efficacy of Success when applied using a mist backpack sprayer, a piece of equipment that may prove valuable to growers who cannot use helicopters in their control efforts. Continued studies in 2000 to determine the relationships between thrips populations on leaves, fruit, leaf flush, and scarring of fruit and predators have added to knowledge gained in 1998 and 1999. This information will and has proven valuable in guiding the industry in the right direction in terms of its options in biological and cultural control practices.

Objectives

The objectives of field studies in Ventura County have been:

1. Determine the most efficacious spray volume to use when applying Veratran D and Agri-Mek by helicopter on small and large trees.
2. Determine efficacy of aerial applications using Success and Agri-Mek against avocado thrips, and to compare them with backpack applications of Success.
3. Determine population trends of avocado thrips on leaves and fruit at 3 untreated orchards in Ventura County, as part of a continual long-term study.
4. Determine the relationships between avocado thrips populations of leaves and fruit and scarring on fruit at these orchards.
5. Determine the abundance of predators on leaves and fruit in these orchards and relate to them to avocado thrips populations.

Summary

Spray volume when applying Veratran D (sabadilla). Three trials using sabadilla (12-25 lbs/acre) plus sugar in volumes of 40-210 gallons per acre (gpa) were conducted from April through June 1999 at sites in Santa Paula, Ventura County, with 'Hass' avocados in commercial orchards on level terrain. One used small (3-m tall) trees and two used large (6-9-m tall) trees. Trials were conducted using a randomized block design, usually composed of three replicates of six treatments each (including the control). Treatments were blocked on pre-treatment numbers of thrips larvae/leaf. Plots were divided evenly into those with lowest, intermediate, and highest numbers, and numbers from the three groups matched to produce similar means. Treatments were randomly assigned within these three groups afterwards. In all volume trials, a helicopter with a 32-ft long boom, with 32 nozzles, was used to make applications. A single pass was made over the one row, 6-17 tree-long replicates. Water-sensitive papers were stapled on leaves to determine spray coverage.

Results of these trials indicated that on small trees with 20 ft spacing, 40 gpa was sufficient to reduce thrips larval populations on leaves. However, in both large tree trials, data indicated that this volume was insufficient. Rather, volumes of 85-125 gpa seemed necessary for effective control. Regardless of volume, effects of sabadilla lasted only 6-13 days. There were positive regressions between spray volume and spray coverage, with greater spray volume producing greater coverage.

Spray volume when applying Agri-Mek (abamectin). Seven aerial spray volume trials using abamectin were conducted in Ventura County from July 1999-May 2000. One was conducted on small (2-3-m tall) trees, one on medium (4-m tall) trees, and five on large (6-8-m tall) trees. Volumes tested ranged from 50-150 gpa, but were usually 50 or 100 gpa. Abamectin was applied as Agri-Mek 0.15EC at 10 or 20 oz/acre with 1% NR 415 oil, and in some trials with Silwet, an organosilicone surfactant. Application methods and equipment were essentially the same as in the sabadilla studies.

The overall results indicated that a high rate of abamectin (20 oz Agri-Mek/a) in an aerial spray volume of 50 gpa delivered via helicopter can reduce larval thrips populations on lower leaves of small, medium, and large (approx. 6 m-tall) trees. However, on the largest (>8-m tall), closed-canopied trees, applying neither 50 nor 100 gpa seems reliable for effective control (at least at 10 oz Agri-Mek/acre) because these spray volumes were insufficient to penetrate the canopy to reach the lower levels. In these situations, it was not surprising that applying even 100 gpa can be ineffective. It appeared that spray coverage of <10% on the bottom of a leaf surface was usually ineffective in causing high mortality when a low abamectin rate was used. To obtain consistent results on these large trees, a volume > 100 gpa may greatly increase spray coverage and probably result in increased efficacy. However, because of costs to growers, such a volume is generally considered impractical for routine helicopter applications and thus was included in only one trial of our study. High spray coverage on large trees would best be accomplished by opening up tight canopies and using 50 gpa.

Efficacy of aerial applications using Success and Agri-Mek. One trial using air applications of Success 2SC (spinosad) and Agri-Mek 0.15 EC (abamectin) and 2 trials using these and a

backpack spinosad application were made against *S. perseae* on small (2.2 m-tall), medium (4-5 m-tall), and large (6-8 m-tall) avocado trees in Ventura County, CA in 1999 and 2000. In all trials, 1% NR 415 oil was added. In the small tree trial only, the organosilicone surfactant Silwet was added.

On small trees, both chemicals in 468 and 935 l/ha (50 and 100 gpa) spray volumes were equally effective when applied by air against *S. perseae* larvae on leaves 20-27 days after treatment (DAT) (Table 1). Adult numbers were generally unaffected by treatments.

On medium trees, air applications of spinosad (83 and 167 ml AI/ha) (5 and 10 oz/acre) were less effective than of abamectin (14 and 28 ml AI/ha) (10 and 20 oz/acre) in a 701 l/ha (75 gpa) spray volume when made approximately 2 weeks before fruit set. The backpack spinosad treatment was the most effective treatment 3-10 days after treatment (DAT), but air abamectin treatments were equally effective 17 DAT. This was generally true when determined by numbers of larvae (Table 2) and adults (Table 3) on leaves and numbers of larvae (Table 4) on fruit. There generally were no differences on numbers of adults on fruit (Table 5). Fruit lengths were not affected by treatments (Table 6), but scarring of fruit was lowest in the abamectin treatments (Table 7). Percentages of fruit with economic scars at 79 DAT ranked (highest to lowest) as follows: control > spinosad air at 5 oz/acre (83 ml AI/ha) > spinosad air at 10 oz/acre (167 ml AI/ha) > spinosad backpack at 10 oz/acre > abamectin air at 10 oz/acre (14 ml AI/ha) = abamectin air at 20 oz/acre (28 ml AI/ha). Predatory mite and predatory thrips numbers on leaves were slightly reduced, especially by the backpack spinosad treatment, but populations recovered after 17 DAT (Tables 8 and 9).

Results on large trees (Table 10) were similar to those in the medium tree trial. In addition, persea mite, *Oligonychus perseae*, numbers were reduced by air abamectin, air spinosad and backpack spinosad applications (Table 11).

Our results suggest that air spinosad and abamectin applications are equally effective against *S. perseae*, but the ability of spinosad to prevent scarring on fruit may be more dependent on precise timing of application because abamectin results in longer control. However, when applied by backpack on medium trees approximately 2 weeks before fruit set or on large trees, spinosad is nearly as or as effective as air abamectin treatments in protecting fruit against *S. perseae* damage.

Population trends of avocado thrips on leaves and fruit. In 2000, we continued to see a similar pattern of thrips infestations on leaves and fruit compared with 1998 and 1999. Thrips larvae were found at significantly higher densities on leaves than fruit early in the season, but densities on fruit reached levels seen on leaves later in the season (Table 12). As in previous years, this seemed related to the hardening of leaves.

Relationships between avocado thrips populations of leaves and fruit and scarring on fruit. In 2000, we continued to follow thrips populations and relate them to scarring on fruit. Unlike in 1998 and 1999, there seemed to no positive relationship between numbers on leaves and scarring on fruit, at least between 2 orchards. At Moore on June 13, there were only 2.72 larvae/leaf, but scarring on July 25 was 19.8%; at Hutter on June 14, there were 6.38 larvae/leaf, but scarring was only 16.9% (Table 12). The apparent lack of relationship seemed related to the asynchronous fruit development; fruit appearing later were subject to higher damage because little young growth was present to keep thrips off the fruit.

Abundance of predators on leaves and fruit. In 2000, populations of predators on leaves in these orchards continued to be low (Table 13), as in 1998 and 1999. A major difference between 2000 and the previous two years was the lack of adult predatory thrips in 2000, and in the relatively high densities of lacewings (0.0107/leaf in 2000 compared with 0.0014/leaf averaged over 1998 and 1999). As in 1998 and 1999, only a few predatory thrips and lacewings were found on fruit.

Most important things learned in 1999-2000 season were:

1. Sabadilla was effective in a 40 gpa spray volume when applied by air on small trees, but >85 gpa were needed on large trees to effectively reduce thrips numbers at lower tree levels.
2. Abamectin was effective in a 50 gpa spray volume when applied by air on small, medium, and large trees. However, such a low volume on large trees often results in low coverage. Under such a situation, highest thrips mortality may be delayed for up to three weeks. On the very largest, close-canopied trees, a volume of 100 gpa was ineffective in reducing thrips populations at lower tree levels. These closed-canopied orchards need to be opened up for successful avocado thrips control.
3. Success is less effective in preventing scarring of fruit than Agri-Mek when applied by air two weeks before fruit set. Backpack application of Success two weeks before fruit set is almost as or as effective as air application of Agri-Mek.
4. For Success to be as effective as Agri-Mek when applied by air, applications may need to be made closer to the time of fruit set, or perhaps even right after fruit set, as long as spray coverage is sufficient.
5. Continued monitoring of thrips populations on fruit and leaves seemed to confirm that thrips prefer leaves over fruit.
6. The relationship between thrips populations and scarring on fruit may be even more complex than once thought, because simple population-scarring predictions may not hold true when there is asynchrony in fruit set as experienced this year, 2000. Numbers of larvae >3/leaf can be related to 20% scarring under conditions of asynchronous fruit set.
7. Continued monitoring of predator abundance in orchards seemed to confirm that naturally-occurring predators persist at densities too low for effective thrips control.

Background Reading

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Table 1. Trial 1: Mean numbers of *S. perseae* larvae and adults/leaf ± SE (60 leaves/replicate, 3 replicates) and results of analyses of variance (ANOVA) and LSD multiple comparisons from spinosad (S, 167 ml AI/ha) - abamectin (A, 28 ml AI/ha) trial in Santa Paula, CA, August 24-September 22, 1999. Means with different letters within rows are significantly different (*P* < 0.05). 468, 935 = l/ha spray volume.

Date	DAT[a]	Control	S, 468	S, 935	A, 468	A, 935	F [b]	P
				Larvae				
Aug 24	-2	4.40 ± 1.04a	4.23 ± 0.44a	4.85 ± 1.30a	4.62 ± 1.25a	4.80 ± 1.13a	0.32	0.8562
30	4	5.04 ± 0.82a	0.62 ± 0.20b	0.53 ± 0.35b	2.04 ± 0.36b	0.75 ± 0.20b	21.40	0.0002
Sep 2	7	5.66 ± 0.56a	1.66 ± 0.56b	1.68 ± 0.77b	3.25 ± 0.08ab	1.88 ± 0.54b	7.31	0.0088
8	13	3.94 ± 1.04a	1.96 ± 0.51a	2.58 ± 0.96a	3.69 ± 0.87a	2.24 ± 0.56a	1.86	0.2114
15	20	2.73 ± 1.04a	0.52 ± 0.18b	0.67 ± 0.35b	0.44 ± 0.12b	0.45 ± 0.05b	5.87	0.0166
22	27	2.84 ± 1.23a	0.26 ± 0.14b	0.28 ± 0.15b	0.16 ± 0.08b	0.13 ± 0.04b	11.61	0.0021
				Adults				
Aug 24	-2	0.56 ± 0.13a	0.46 ± 0.05a	0.62 ± 0.07a	0.81 ± 0.13a	4.80 ± 1.13a	1.51	0.2872
30	4	0.30 ± 0.82a	0.03 ± 0.01b	0.07 ± 0.03b	0.13 ± 0.10b	0.75 ± 0.20b	5.89	0.0165
Sep 2	7	0.33 ± 0.20a	0.19 ± 0.13a	0.16 ± 0.11a	0.27 ± 0.17a	0.22 ± 0.07a	0.74	0.5903
8	13	0.22 ± 0.11a	0.06 ± 0.02a	0.07 ± 0.02a	0.13 ± 0.10a	0.07 ± 0.02a	1.08	0.4284
15	20	0.20 ± 0.08a	0.04 ± 0.02a	0.11 ± 0.05a	0.07 ± 0.06a	0.11 ± 0.06a	1.91	0.2023
22	27	0.41 ± 0.15a	0.11 ± 0.05a	0.24 ± 0.16a	0.13 ± 0.13a	0.16 ± 0.07a	1.69	0.2453

[a]Days after treatment.
[b]All df = 4, 8.

Table 2. Trial 2: Mean numbers of *S. perseae* larvae/leaf ± SE (60 leaves/replicate, 3 replicates) and results of analyses of variance (ANOVA) and LSD multiple comparisons from spinosad (S) - abamectin (A) trial in Santa Paula, CA, May 16-August 10, 2000. Means with different letters within rows are significantly different (P < 0.05). 83, 167, 14, and 28 = ml AI/ha.

Date	DAT[a]	Control	S-83 Air	S-167 Air	A-14 Air	A-28 Air	S-67 Backpack	*F* [b]	*P*
May 16-18	-7 to -5	16.4 ± 6.3a	16.3 ± 2.6a	16.8 ± 2.2a	16.9 ± 4.8a	16.2 ± 3.6a	16.3 ± 4.6a	0.55	0.733
26	3	12.2 ± 5.0a	2.3 ± 0.7b	2.0 ± 0.8bc	2.3 ± 0.7b	2.0 ± 0.3bc	0.4 ± 0.2c	11.25	0.0008
30	7	16.4 ± 6.0a	8.7 ± 2.4b	6.3 ± 1.4bc	5.2 ± 2.0bc	3.4 ± 0.7c	0.7 ± 0.3d	14.85	0.0002
June 2	10	16.9 ± 7.6a	12.4 ± 2.7ab	9.1 ± 1.6ab	7.9 ± 2.6ab	5.3 ± 1.1b	0.6 ± 0.1c	8.16	0.0026
9	17	14.5 ± 6.4a	5.9 ± 1.2b	4.8 ± 1.0bc	1.7 ± 0.5cd	0.7 ± 0.2d	0.4 ± 0.1d	14.77	0.0002
16	24	24.2 ± 7.6a	8.7 ± 2.9b	4.1 ± 1.1b	0.8 ± 0.4c	0.2 ± 0.1c	0.2 ± 0.1c	23.14	<0.0001
27	35	19.5 ± 8.1a	12.3 ± 2.8ab	10.7 ± 2.2ab	1.9 ± 0.5c	1.2 ± 0.3c	4.6 ± 1.1bc	6.36	0.0066
July 5	43[c]	12.1 ± 4.0a	10.2 ± 3.7ab	15.9 ± 4.4a	3.9 ± 0.7b	3.8 ± 1.2b	9.1 ± 2.3ab	3.36	0.0488
11	49[c]	12.2 ± 5.6a	7.5 ± 2.3a	8.9 ± 1.0a	2.9 ± 1.4a	1.8 ± 0.5a	6.8 ± 2.9a	2.40	0.1118
27	65[d]	13.2 ± 5.2a	7.5 ± 3.2ab	5.6 ± 1.8abc	3.9 ± 2.2bc	1.6 ± 0.2c	6.4 ± 2.1abc	3.38	0.0477
Aug 10	79[d]	11.4 ± 5.0a	7.8 ± 2.8a	14.5 ± 3.4a	6.6 ± 0.6a	4.6 ± 1.4a	16.6 ± 7.0a	2.51	0.1010

[a]Days after treament.
[b]All df = 5, 10.
[c]N = 30 leaves/replicate.
[d]N = 20 leaves/replicate.

Table 3. Trial 2: Mean numbers of *S. perseae* adults/leaf ± SE (60 leaves/replicate, 3 replicates) and results of analyses of variance (ANOVA) and LSD multiple comparisons from spinosad (S) - abamectin (A) trial in Santa Paula, CA, May 16-August 10, 2000. Means with different letters within rows are significantly different (P < 0.05). 83, 167, 14, and 28 = ml AI/ha.

Date	DAT[a]	Control	S-83 Air	S-167 Air	A-14 Air	A-28 Air	S-167 Backpack	*F* [b]	*P*
May 16-18	-7 to -5	0.89 ± 0.03a	1.15 ± 0.14a	0.84 ± 0.22a	1.05 ± 0.24a	1.10 ± 012a	0.89 ± 0.14a	0.48	0.7810
26	3	1.59 ± 0.42a	0.40 ± 0.12b	0.25 ± 0.08bc	0.54 ± 0.13b	0.58 ± 0.04b	0.06 ± 0.03c	10.24	0.0011
30	7	1.78 ± 0.26a	0.88 ± 0.12b	0.84 ± 0.11b	0.89 ± 0.28b	0.70 ± 0.06b	0.18 ± 0.04c	11.05	0.0008
June 2	10	1.38 ± 0.40a	1.02 ± 0.28ab	0.62 ± 0.05bc	0.51 ± 0.06bc	0.46 ± 0.03c	0.10 ± 0.04d	9.63	0.0014
9	17	1.28 ± 0.24a	0.56 ± 0.13b	0.27 ± 0.06bc	0.10 ± 0.01c	0.15 ± 0.09c	0.17 ± 0.06c	10.54	0.0010
16	24	1.11 ± 0.44a	1.16 ± 0.14a	0.61 ± 0.05ab	0.22 ± 0.03b	0.26 ± 0.11b	0.54 ± 0.25ab	3.72	0.0366
27	35	1.13 ± 0.32a	0.44 ± 0.12b	0.42 ± 0.11b	0.17 ± 0.04c	0.18 ± 0.04c	0.43 ± 0.06b	13.81	0.0003
July 5	43[c]	1.03 ± 0.36a	0.77 ± 0.25ab	0.38 ± 0.01bc	0.19 ± 0.02cd	0.06 ± 0.01d	0.20 ± 0.05cd	6.75	0.0053
11	49[c]	0.92 ± 0.34a	0.50 ± 0.15a	0.50 ± 0.18a	0.22 ± 0.12a	0.08 ± 0.04a	0.42 ± 0.14a	2.44	0.1082
27	65[d]	0.70 ± 0.25a	0.62 ± 0.25a	0.53 ± 0.06a	0.35 ± 0.14a	0.17 ± 0.06a	0.50 ± 0.23a	1.35	0.3208
Aug 10	79[d]	0.87 ± 0.33a	0.90 ± 0.10a	2.12 ± 0.88b	0.92 ± 0.18a	0.48 ± 0.16a	1.08 ± 0.31ab	3.35	0.0491

[a]Days after treament.
[b]All df = 5, 10.
[c]*N* = 30 leaves/replicate.
[d]*N* = 20 leaves/replicate.

Table 4. Trial 2: Mean numbers of *S. perseae* larvae/fruit ± SE (30 fruit/replicate, 3 replicates) and results of analyses of variance and LSD multiple comparisons from spinosad (S) - abamectin (A) trial in Santa Paula, CA, June 2-August 10, 2000. Means with different letters within rows are significantly different (P < 0.05). 83, 167, 14, and 28 = ml AI/ha.

Date	DAT[a]	Control	S-83 Air	S-167 Air	A-14 Air	A-28 Air	S-167 Backpack	*F* [b]	*P*
June 2	10c	0.07 ± 0.03	0.07	0.00 ± 0.00	0.03	0.00	0.00 ± 0.00	----	-----
8	16	0.13 ± 0.02a	0.10 ± 0.02a	0.03 ± 0.02bc	0.06 ± 0.01ab	0.01 ± 0.01cd	0.00 ± 0.00d	9.70	0.0014
15	23	0.18 ± 0.08a	0.09 ± 0.07ab	0.00 ± 0.00c	0.00 ± 0.00c	0.01 ± 0.01bc	0.00 ± 0.00c	7.74	0.0032
26	34[d]	1.30 ± 0.60a	0.53 ± 0.42ab	0.38 ± 0.15abc	0.03 ± 0.03bc	0.01 ± 0.01c	0.07 ± 0.05bc	5.08	0.0142
July 3	41	1.78 ± 1.31a	1.18 ± 0.80a	1.48 ± 0.85a	0.11 ± 0.10a	0.03 ± 0.02a	0.54 ± 0.28a	1.46	0.2841
10	48[e]	2.01 ± 1.40a	1.11 ± 0.98a	1.54 ± 0.66a	0.09 ± 0.06a	0.00 ± 0.00a	0.91 ± 0.39a	1.06	0.4375
25	63[f]	4.20 ± 3.09a	1.75 ± 1.30a	1.63 ± 0.53a	0.53 ± 0.23a	0.40 ± 0.18a	0.97 ± 0.32a	1.76	0.2093
Aug 10	79[f]	2.37 ± 1.35a	1.90 ± 1.00a	2.80 ± 0.48a	0.99 ± 0.59a	0.58 ± 0.32a	1.97 ± 1.05a	1.47	0.2806

[a]Days after treament.
[b]All df = 5, 10.
[c]1 -3 replicates per treatment; data not analyzed.
[d]*N*= 60 fruit/replicate
[e]*N* = 20-30 fruit/replicate.
[f]*N* = 12-20 fruit/replicate.

Table 5. Trial 2: Mean numbers of *S. perseae* adults/fruit ± SE (30 fruit/replicate, 3 replicates) and results of analyses of variance (ANOVA) and LSD multiple comparisons from spinosad (S) - abamectin (A) trial in Santa Paula, CA, June 2-August 10, 2000. Means with different letters within rows are significantly different (P < 0.05). 83, 167, 14, and 28 = ml AI/ha.

Date	DAT[a]	Control	S-83 Air	S-167 Air	A-14 Air	A-28 Air	S-167 Backpack	*F* [b]	*P*
June 2	10[c]	0.00 ± 0.00	0.07	0.00 ± 0.00	0.00	0.03	0.02 ± 0.01	----	-----
8	16	0.04 ± 0.03a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	0.00 ± 0.00a	3.29	0.0514
15	23	0.04 ± 0.03a	0.03 ± 0.02a	0.02 ± 0.01a	0.02 ± 0.01a	0.00 ± 0.00a	0.01 ± 0.01a	1.09	0.4228
26	34[d]	0.13 ± 0.07a	0.11 ± 0.09a	0.06 ± 0.03a	0.01 ± 0.01a	0.02 ± 0.00a	0.06 ± 0.03a	1.66	0.2320
July 3	41	0.24 ± 0.12a	0.13 ± 0.05a	0.10 ± 0.04a	0.09 ± 0.03ab	0.03 ± 0.03b	0.09 ± 0.03ab	3.64	0.0389
10	48[e]	0.21 ± 0.12a	0.11 ± 0.10a	0.13 ± 0.06a	0.01 ± 0.01a	0.00 ± 0.00a	0.09 ± 0.04a	1.52	0.2669
25	63[f]	0.15 ± 0.10a	0.13 ± 0.02a	0.35 ± 0.08a	0.05 ± 0.03a	0.13 ± 0.07a	0.25 ± 0.00a	2.11	0.1475
Aug 10	79[f]	0.07 ± 0.07a	0.10 ± 0.10a	0.21 ± 0.08a	0.05 ± 0.05a	0.11 ± 0.07a	0.14 ± 0.04a	0.62	0.6887

[a]Days after treament.
[b]All df = 5, 10.
[c]1 -3 replicates per treatment; data not analyzed.
[d]*N* = 60 fruit/replicate.
[e]*N* = 20-30 fruit/plot.
[f]*N* = 12-20 fruit/plot.

Table 6. Trial 2: Mean fruit lengths (cm) ± SE (30 fruit/replicate, 3 replicates) and results of analyses of variance (ANOVA) and LSD multiple comparisons from spinosad (S) - abamectin (A) trial in Santa Paula, CA, June 8-August 10, 2000. There were no significant differences within rows. 83, 167, 14, and 28 = ml AI/ha.

Date	**DAT**[a]	**Control**	**S-83 Air**	**S-167 Air**	**A-14 Air**	**A-28 Air**	**S-167 Backpack**	***F*** [b]	***P***
June 8	16	0.51 ± 0.50	0.50 ± 0.02	0.46 ± 0.02	0.49 ± 0.02	0.50 ± 0.07	0.51 ± 0.03	0.19	0.9576
15	23	0.62 ± 0.07	0.60 ± 0.04	0.57 ± 0.04	0.60 ± 0.03	0.59 ± 0.06	0.59 ± 0.06	0.29	0.9093
26	34[c]	1.04 ± 0.19	0.94 ± 0.25	0.93 ± 0.07	0.94 ± 0.05	1.00 ± 0.16	0.95 ± 0.10	0.13	0.9825
July 3	41	1.63 ± 0.36	1.24 ± 0.25	1.47 ± 0.26	1.62 ± 0.08	1.56 ± 0.23	1.49 ± 0.25	0.65	0.6679
10	48[d]	1.95 ± 0.33	2.01 ± 0.16	2.09 ± 0.09	2.12 ± 0.15	2.15 ± 0.12	1.98 ± 0.08	0.23	0.9394
25	63[e]	3.24 ± 0.62	2.95 ± 0.74	3.65 ± 0.32	3.34 ± 0.71	3.69 ± 0.30	3.43 ± 0.35	0.25	0.9289
Aug 10	79[e]	4.34 ± 0.49	4.15 ± 0.35	5.18 ± 0.22	4.81 ± 0.44	5.44 ± 0.48	5.19 ± 0.39	1.40	0.3027

[a]Days after treament.
[b]All df = 5, 10.
[c]*N* = 60 fruit/plot.
[d]*N* = 20-30 fruit/replicate.
[e]*N* = 12-20 fruit/replicate.

Table 7. Trial 2: Mean percentage of fruit with scars ± SE (x 100) and mean percentage with economic scarring damage ± SE (30 fruit/replicate) caused by *S. perseae* and results of analyses of variance (ANOVA) and LSD multiple comparisons from spinosad (S) - abamectin (A) trial in Santa Paula, CA, June 8-August 10, 2000. Means with different letters within rows are significantly different (P < 0.05). 83, 167, 14, and 28 = ml AI/ha.

				Mean Percentage of Fruit with Scars					
Date	**DAT**[a]	**Control**	**S-83 Air**	**S-167 Air**	**A-14 Air**	**A-28 Air**	**S-167 Backpack**	***F*** [b]	***P***
June 8	16	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	----	-----
15	23	3 ± 3a	4 ± 1a	0 ± 0a	0 ± 0a	1 ± 1a	0 ± 0a	2.98	0.0668
26	34[c]	33 ± 15a	17 ± 12ab	11 ± 2abc	2 ± 1cd	1 ± 1d	2 ± 1bcd	5.96	0.0083
July 3	41	47 ± 20a	24 ± 8ab	20 ± 8abc	4 ± 1bc	2 ± 1c	14 ± 3abc	4.01	0.0294
10	48[d]	52 ± 12a	37 ± 10a	32 ± 4a	6 ± 3b	3 ± 2b	13 ± 5b	7.36	0.0039
25	63[e]	55 ± 13a	42 ± 17ab	33 ± 6abc	10 ± 8c	8 ± 4c	13 ± 4bc	3.74	0.0361
Aug 10	79[e]	50 ± 10a	49 ± 10a	52 ± 4a	30 ± 2a	27 ± 8a	33 ± 8a	2.09	0.1502
				Mean Percentage with Economic Scarring Damage					
Date	**DAT**[a]	**Control**	**S-83 Air**	**S-167 Air**	**A-14 Air**	**A-28 Air**	**S-167 Backpack**	***F*** [b]	***P***
June 8	16	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	----	-----
15	23	1 ± 1a	2 ± 1a	0 ± 0a	0 ± 0a	1 ± 1a	0 ± 0a	1.82	0.1969
26	34[c]	21 ± 11a	9 ± 6ab	7 ± 2bc	1 ± 1d	0 ± 0d	1 ± 1cd	8.44	0.0023
July 3	41	33 ± 14a	17 ± 8ab	14 ± 6ab	2 ± 2c	0 ± 0c	4 ± 2bc	5.90	0.0086
10	48[d]	29 ± 13a	21 ± 10ab	18 ± 6ab	2 ± 2cd	0 ± 0d	6 ± 2bc	9.31	0.0016
25	63[e]	18 ± 7a	18 ± 13a	8 ± 6a	3 ± 2a	0 ± 0a	2 ± 2a	3.20	0.0555
Aug 10	79[e]	24 ± 9a	20 ± 10a	14 ± 4a	2 ± 2a	2 ± 2a	9 ± 2a	3.01	0.0651

[a]Days after treatment.
[b]All df = 5, 10.
[c]*N* = 60 fruit/replicate.
[d]*N* = 20-30 fruit/replicate.
[e]*N* = 12-20 fruit/replicate.

Table 8. Trial 2: Mean numbers of predatory mites ± SE (60 leaves/replicates, 3 replicates) and results of analyses of variance (ANOVA) and LSD multiple comparisons from spinosad (S) - abamectin (A) trial in Santa Paula, CA, May 16-August 10, 2000. Means with different letters within rows are significantly different (P < 0.05). 83, 167, 14, and 28 = ml AI/ha.

Date	**DAT**[a]	**Control**	**S-83 Air**	**S-167 Air**	**A-14 Air**	**A-28 Air**	**S-167 Backpack**	***F*** [b]	***P***
May 16-18	-5 to -7	0.48 ± 0.16a	0.53 ± 0.21a	0.61 ± 0.02a	0.85 ± 0.17a	0.52 ± 0.23a	0.57 ± 0.18a	0.82	0.5600
26	3	0.82 ± 0.34a	0.45 ± 0.11a	0.64 ± 0.18a	0.65 ± 0.16a	0.36 ± 0.15ab	0.07 ± 0.03b	3.42	0.0465
30	7	0.94 ± 0.41ab	0.65 ± 0.31ab	0.88 ± 0.10a	0.79 ± 0.28ab	0.28 ± 0.12bc	0.12 ± 0.07c	3.54	0.0420
June 2	10	0.79 ± 0.36ab	0.65 ± 0.27ab	0.89 ± 0.17a	0.57 ± 0.10ab	0.23 ± 0.13bc	0.07 ± 0.01c	3.93	0.0313
9	17	0.31 ± 0.15a	0.23 ± 0.11a	0.35 ± 0.04a	0.27 ± 0.13a	0.11 ± 0.07a	0.10 ± 0.04a	0.94	0.4937
16	24	0.35 ± 0.19a	0.36 ± 0.20a	0.45 ± 0.07a	0.49 ± 0.12a	0.23 ± 0.17a	0.18 ± 0.09a	0.99	0.4688
27	35	0.16 ± 0.08a	0.14 ± 0.10a	0.21 ± 0.09a	0.16 ± 0.07a	0.08 ± 0.07a	0.18 ± 0.04a	0.73	0.6187
July 5	43[c]	0.12 ± 0.08a	0.08 ± 0.06a	0.09 ± 0.04a	0.07 ± 0.05a	0.06 ± 0.06a	0.10 ± 0.03a	0.39	0.8441
11	49[c]	0.07 ± 0.03a	0.10 ± 0.06a	0.10 ± 0.03a	0.07 ± 0.04a	0.03 ± 0.03a	0.02 ± 0.02a	0.81	0.5683
27	65[d]	0.00 ± 0.00a	0.03 ± 0.03a	0.02 ± 0.02a	0.05 ± 0.05a	0.00 ± 0.00a	0.02 ± 0.02a	0.54	0.7424
Aug 10	79[d]	0.05 ± 0.03a	0.02 ± 0.02a	0.08 ± 0.03a	0.02 ± 0.02a	0.00 ± 0.00a	0.02 ± 0.02a	1.74	0.2129

[a]Days after treament.
[b]All df = 5, 10.
[c]*N* = 30 leaves/replicate.
[d]*N* = 20 leaves/replicate.

Table 9. Trial 2: Mean numbers of predatory thrips ± SE (60 leaves/replicate, 3 replicates) and results of analyses of variance (ANOVA) and LSD multiple comparisons from spinosad (S) - abamectin (A) trial in Santa Paula, CA, May 16-August 10, 2000. Means with different letters within rows are significantly different (P < 0.05). 83, 167, 14, and 28 = ml AI/ha.

Date	**DAT**[a]	**Control**	**S-83 Air**	**S-167 Air**	**A-14 Air**	**A-28 Air**	**S-167 Backpack**	***F*** [b]	***P***
May 16-18	-5 to -7	0.04 ± 0.02a	0.03 ± 0.01a	0.03 ± 0.01a	0.03 ± 0.02a	0.03 ± 0.02a	0.03 ± 0.01a	0.07	0.9951
26	3	0.06 ± 0.02ab	0.03 ± 0.02abc	0.02 ± 0.02bc	0.07 ± 0.02a	0.02 ± 0.00bc	0.01 ± 0.01c	3.63	0.0393
30	7	0.10 ± 0.02a	0.03 ± 0.01a	0.06 ± 0.02a	0.06 ± 0.02a	0.05 ± 0.02a	0.02 ± 0.01a	3.19	0.0559
June 2	10	0.14 ± 0.04a	0.08 ± 0.04a	0.12 ± 0.03a	0.13 ± 0.03a	0.10 ± 0.02a	0.04 ± 0.02a	1.52	0.2665
9	17	0.21 ± 0.09a	0.06 ± 0.01a	0.07 ± 0.01a	0.08 ± 0.01a	0.04 ± 0.02a	0.03 ± 0.02a	3.22	0.0544
16	24	0.07 ± 0.02a	0.08 ± 0.01a	0.01 ± 0.01a	0.04 ± 0.02a	0.02 ± 0.00a	0.01 ± 0.01a	3.04	0.0634
27	35	0.01 ± 0.01a	0.03 ± 0.01a	0.01 ± 0.01a	0.00 ± 0.00a	0.00 ± 0.00a	0.01 ± 0.01a	2.40	0.1119
July 5	43[c]	0.02 ± 0.02a	0.03 ± 0.02a	0.03 ± 0.02a	0.00 ± 0.00a	0.00 ± 0.00a	0.01 ± 0.01a	1.92	0.1785
11	49[c]	0.02 ± 0.02a	0.02 ± 0.02a	0.02 ± 0.02a	0.02 ± 0.02a	0.00 ± 0.00a	0.00 ± 0.00a	0.35	0.8723
27	65[d]	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	-----	-----
Aug 10	79[d]	0.00 ± 0.00a	0.02 ± 0.02a	0.02 ± 0.02a	0.03 ± 0.03a	0.02 ± 0.02a	0.02 ± 0.02a	0.19	0.9578

[a]Days after treament.
[b]All df = 5, 10.
[c]*N* = 30 leaves/replicate.
[d]*N* = 20 leaves/replicate.

Table 10. Trial 3: Mean numbers of *S. perseae* larvae and adults ± SE (30 leaves/replicate, 3 replicates) and results of analyses of variance (ANOVA) and LSD multiple comparisons from spinosad (S) - abamectin (A) trial in Santa Paula, CA, August 29, 2000-September 15, 2000. Means with different letters within rows are significantly different (P < 0.05). 167 and 28 = ml AI/ha.

Date	DAT[a]	Control	S-167[b] Air	A-28 Air	S-167 Backpack	*F* [c]	*P*
				***S. perseae* Larvae**			
Aug 21	-8	2.73 ± 0.29a	4.85 ± 0.78a	4.18 ± 0.19a	4.70 ± 1.29a	1.30	0.3589
25	-4	3.48 ± 0.28a	4.92 ± 1.81a	5.01 ± 1.26a	3.88 ± 1.73a	0.36	0.7823
Sept 1	3	8.51 ± 2.50a	3.09 ± 0.48b	3.74 ± 1.37b	0.06 ± 0.03c	21.67	0.0013
5	7	8.29 ± 1.92a	6.15 ± 1.91ab	3.42 ± 1.00b	0.27 ± 0.02c	25.80	0.0008
15	17	5.57 ± 2.10a	2.24 ± 0.56b	0.74 ± 0.49bc	0.13 ± 0.05c	18.22	0.0020
				***S. perseae* Adults**			
Aug 21	-8	1.61 ± 0.33a	1.67 ± 0.55a	1.98 ± 0.04a	1.82 ± 0.46a	0.32	0.8127
25	-4	0.90 ± 0.38a	1.22 ± 0.29a	1.07 ± 0.03a	1.05 ± 0.51a	0.41	0.7549
Sept 1	3	1.25 ± 0.55a	0.70 ± 0.22a	0.51 ± 0.10ab	0.10 ± 0.04b	6.74	0.0238
5	7	1.68 ± 0.36a	0.91 ± 0.26a	1.36 ± 0.58a	0.34 ± 0.14a	4.30	0.0610
15	17	2.49 ± 0.39a	1.01 ± 0.53a	1.09 ± 0.41a	0.70 ± 0.33a	4.03	0.0691

[a]Days after treatment
[b]Possibly some abamectin residue in spinosad spray because the emptied helicopter tank was not rinsed with water after abamectin and before spinosad applications.
[c]All df = 3, 6.

Table 11. Trial 3: Mean numbers of O. perseae on young leaves (full leaf counts) and old leaves (second half vein counts) ± SE (30 leaves/replicate, 3 replicates) and results of analyses of variance (ANOVA) and LSD multiple comparisons from spinosad (S) - abamectin (A) trial in Santa Paula, CA, August 29, 2000-September 15, 2000. Means with different letters within rows are significantly different (P < 0.05). 167 and 28 = ml AI/ha.

Date	**DAT**[a]	**Control**	**S-167**[b] **Air**	**A-28 Air**	**S-167 Backpack**	***F*** [c]	***P***
			O. perseae on Young Leaves (Full Leaf Counts)				
August 25	-4	5.52 ± 1.48a	9.09 ± 4.54a	8.50 ± 1.59a	6.66 ± 4.22a	0.26	0.8522
September 1	3	19.61 ± 2.76a	11.44 ± 3.47b	9.81 ± 3.23b	3.11 ± 1.13c	19.69	0.0017
5	7	34.61 ± 9.21a	16.91 ± 5.29b	11.30 ± 0.91b	8.95 ± 1.13b	7.88	0.0167
15	17	60.19 ± 3.93a	35.22 ± 7.49b	25.70 ± 6.31b	30.50 ± 11.64b	6.51	0.0258
			O. perseae on Old Leaves (Second Half Vein Counts)				
August 25	-4	9.50 ± 1.58a	9.20 ± 2.04a	8.08 ± 1.18a	7.32 ± 3.66a	0.82	0.5272
September 5	7	23.68 ± 0.70a	15.52 ± 3.29a	13.11 ± 1.99a	10.18 ± 3.74a	4.32	0.0604

[a]Days after treatment.
[b]Possibly some abamectin residue in spinosad spray because the emptied helicopter tank was not rinsed with water after abamectin and before spinosad applications.
[c]All df = 3, 6.

Table 12. Comparsion of mean numbers of thrips larvae on leaves and fruit (100 of each) at 3 untreated orchards in Ventura County, 2000.

	Moore				**Hutter**				**Wehr**		
	Leaves	**Fruit**	**% scarred**[a]		**Fruit**	**Leaves**	**% scarred**[a]		**Leaves**	**Fruit**	**% scarred**[a]
June 13	2.72*	1.18	4.1	June 14	6.38***	1.03	2.1	June 14	3.06***	0.25	1.0
June 21	4.06	2.19	10.1	June 23	5.36***	0.76	4.6	June 23	1.35	0.96	4.4
June 27	2.13	2.14	12.2	June 30	3.03*	1.00	9.8	June 30	0.21	0.13	8.0
July 11	0.85	1.15	15.8	July 13	3.70	2.33	13.7	July 5	0.09	0.12	6.2
July 18	0.35	0.43	20.0	July 21	4.06	3.73	16.9	July 12	0.07	0.13	8.2
July 25	0.02	0.11	19.8	July 26	0.00	0.07	5.6				

[a]Those with 10% or more of surface with scarring.
Between leaves and fruit: *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$, Mann-Whitney U-test or t-test.

Table 13. Comparsion of mean numbers of adult and larval thrips, other prey, and associated predators (all stages except eggs) on leaves (100 leaves/date) in 3 untreated orchards in Ventura County, January to August 2000, ranked in order of abundance.

	Mean Numbers/leaf (100 leaves/sampling date)			
Prey	**Jan-Mar**	**April-June**	**July-August**	**Overall Mean**
Persea mite, *Oligonychus perseae*	4.7351	4.0886	0.6520	3.1586
Avocado thrips, *Scirtothrips perseae*	2.1640	2.8287	2.4885	2.4937
Brown mite, *Oligonychus punicae*	0.0596	0.0000	0.8900	0.3165
Predators				
Predatory mites[a]	0.2542	0.7968	0.3660	0.4723
Spiders	0.0303	0.0067	0.0115	0.0162
Green lacewings, *Chrysopa carnea*	0.0018	0.0128	0.0175	0.0107
Predatory thrips[b],	0.0004	0.0208	0.0000	0.0071
Coccinellidae (other than *Stethorus*)	0.0067	0.0018	0.0120	0.0068
Stethorus sp.	0.0013	0.0007	0.0000	0.0028
Feltiella sp.	0.0061	0.0004	0.0000	0.0022
Six-spotted thrips, *Scolothrips* sp.	0.0013	0.0007	0.0000	0.0007
Brown lacewings	0.0005	0.0007	0.0000	0.0004
Syrphidae	0.0000	0.0000	0.0000	0.0000
Oligota oviformis	0.0000	0.0000	0.0000	0.0000

[a]Primarily *Eusieus hibisci*
[b]*Franklinothrips* sp., *Leptothrips mali*, and *Aeolothrips* sp.