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Avocado Thrips Subproject 3: Pesticide Screening, Sabadilla Resistance, *Goetheana* and Lacewing Studies

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Benefit to the Industry

Effective yet selective (nondisruptive to other pests and natural enemies) pesticides are needed for control of avocado thrips. Potential natural enemies which might be augmentatively or inoculatively released should be evaluated and integrated with useful pesticides.

Our strategy in conducting this portion of the project is to lean heavily on what we have learned regarding the biology and control of citrus thrips in prioritizing research needed on avocado thrips.

Objectives

Objectives as listed in 6-98 grant submission:

1. Grow avocado plants for the avocado thrips greenhouse colony.
2. Do preliminary laboratory and field pesticide screening against avocado thrips. Prioritize materials to be evaluated in later field trials and coordinate with trials conducted by Phillips and Faber.
3. Develop a method for monitoring avocado thrips populations for sabadilla resistance and obtain baseline resistance levels at several field sites before and after sabadilla is used extensively.
4. Import *Goetheana incerta* from South Africa and evaluate it against avocado thrips.
5. Working with Cressida Silvers (M. S. student) and Mark Hoddle, evaluate inundative lacewing releases for avocado thrips control.
6. Oversee pesticide spray trials for persea mite.

Recent Project Activity and Future Plans

<u>Project 1</u> Develop an avocado thrips colony for use in laboratory research.

To date, we have been unsuccessful in attempting to develop an avocado thrips colony and this has slowed possible laboratory research somewhat. As a result of not having a colony, both the Morse and Hoddle subprojects are forced to used field-collected avocado thrips and as necessary, citrus thrips as a proxy for avocado thrips.

Avocado thrips were field collected during spring 1998 and placed on Hass seedlings grown in our rearing Agricultural Operations greenhouse by Pamela Watkins. Unfortunately, the controlled environment walkin room (Room 6, Basement of Entomology Annex II) lost cooling capacity July - September and the colony was lost during the summer. Based on temperature studies done by Hoddle, we conducted a number of preliminary studies, none of which were definitive but it appears that avocado thrips does not do at all well at temperatures in excess of a constant 80-85°F. We know have temperature control in this walkin and will be renewing our attempts at getting a colony going using Hass, Lamb Hass, and Reed seedlings.

<u>Future Project A</u> - Continue in our attempts to develop a colony of avocado thrips for use in laboratory research. Avocado thrips will be collected from the field and placed on seedlings in another attempt at establishing a colony.

<u>Project 2</u> Laboratory and field preliminary pesticide screening

<u>Project 2a</u> Determine toxicity of spinosad and chlorfenapyr to avocado thrips for comparison to what we already know about toxicity of these materials to citrus thrips.

> <u>Rationale.</u> We have considerable field and laboratory data on the effect of various pesticides on citrus thrips. A simple first step was to determine the baseline toxicity of two of the more promising pesticides from citrus thrips research on avocado thrips.

Data in Tables 1 and 2 are from: Khan, I. and J. G. Morse. 1998. Citrus thrips (Thysanoptera: Thripidae) resistance monitoring in California. J. Econ. Entomol. 91: 361-366.

Table 1. Toxicity of chlorfenapyr to adult female citrus thrips collected from various sites in California in 1996

Date tested	Site (region)	Slope ± SE	LC_{50} (mg [AI]/liter) (95% FL)	LC_{90} (mg [AI]/liter) (95% FL)	RR_{50}	RR_{90}
10/9/96	Site 1 (Ventura County)	2.18 ± 0.29	0.1304a (0.09683--0.1653)	0.5054a (0.3787--0.7740)	1.0	1.0
10/9/96	Site 2 (Ventura County)	1.93 ± 0.42	0.2159ab (0.1572--0.2879)	0.9984abcde (0.6085--3.144)	1.7	2.0
31/7/96	Site 3 (Southern California)	1.79 ± 0.22	0.1565a (0.1188--0.1980)	0.8158abc (0.5847--1.337)	1.2	1.6
8/8/96	Site 4 (Southern California)	2.22 ± 0.28	0.2666b (0.2045--0.3392)	1.005abcd (0.7336--1.597)	2.0	2.0
4/9/96	Site 5 (Coachella Valley)	2.30 ± 0.32	0.4865c (0.3936--0.5940)	1.759cde (1.284--2.932)	3.7	3.5
4/9/96	Site 6 (Coachella Valley)	2.52 ± 0.29	0.3259b (0.2713--0.3908)	1.051bc (0.8054--1.550)	2.5	2.1
15/8/96	Site 7 (San Joaquin Valley)	1.09 ± 0.21	0.2339ab (0.1582--0.3471)	3.507de (1.569--19.05)	1.8	6.9
15/8/96	Site 8 (San Joaquin Valley)	1.16 ± 0.19	0.3238bc (0.2080--0.4754)	4.130e (2.155--13.40)	2.5	8.2
23/9/96	Site 10 (San Joaquin Valley)	2.95 ± 0.32	0.2690b (0.2280--0.3141)	0.7315ab (0.5920--0.9833)	2.1	1.4

Means within a column followed by the same letter are not significantly different as determined by overlap of 95% FL. Resistance ratios (RR) are calculated in relation to the mean LC_{50} or LC_{90} of site 1 (LC_{50} or LC_{90} of indicated collection/LC_{50} or LC_{90} of site 1).

Mean LC_{50} (concentration necessary to kill 50% of the population) and LC90 for citrus thrips (average of 9 sites exclusive of Site 7): 0.2718 and 1.375 mg [AI]/liter.Comparison data for avocado thrips:

Date tested	Site (region)	Slope ± SE	LC_{50} (mg [AI]/liter) (95% FL)	LC_{90} (mg [AI]/liter) (95% FL)	RR_{50}	RR_{90}
29/10/97	Carpinteria (Ventura County)	1.74 ± 0.30	0.6559 (0.3780-1.205)	3.578 (1.765-16.30)	5.0	7.1

Conclusion: Comparing the Carpinteria avocado thrips data to the mean values for citrus thrips, avocado thrips is somewhat more tolerant of chlorfenapyr than is citrus thrips (it takes 2.4 (0.6559 / 0.2718) and 2.6-fold more chlorfenapyr to kill 50 and 90% of avocado thrips compared with citrus thrips).

Table 2. Toxicity of spinosad to adult female citrus thrips collected from various sites in California in 1996

Date tested	Site (region)	Slope ± SE	LC_{50} (mg [AI]/liter) (95% FL)	LC_{90} (mg [AI]/liter) (95% FL)	RR_{50}	RR_{90}
8/10/96	Site 2 (Ventura County)	2.38 ± 0.41	1.326ab (0.9401--1.654)	4.585b (3.502--7.389)	1.7	2.2
31/7/96	Site 3 (Southern California)	2.90 ± 0.42	1.279b (1.048--1.560)	3.533ab (2.633--5.597)	1.6	1.7
17/9/96	Site 4 (Southern California)	2.50 ± 0.53	0.8147a (0.6522--1.023)	2.658ab (1.796--6.514)	1.0	1.3
25/7/96	Site 5 (Coachella Valley)	2.03 ± 0.33	0.9013ab (0.5980--1.173)	3.847ab (2.896--6.109)	1.1	1.8
15/7/96	Site 6 (Coachella Valley)	2.88 ± 0.38	1.082ab (0.8812--1.295)	3.013ab (2.376--4.306)	1.4	1.4
15/8/96	Site 7 (San Joaquin Valley)	3.07 ± 0.47	0.7988a (0.6149--0.9691)	2.086a (1.668--2.955)	1.0	1.0
15/8/96	Site 8 (San Joaquin Valley)	2.15 ± 0.27	1.364b (1.073--1.697)	5.371b (3.943--8.531)	1.7	2.6
23/9/96	Site 10 (San Joaquin Valley)	2.08 ± 0.51	0.8777ab (0.5875--1.102)	3.633ab (2.400--10.98)	1.1	1.7

Means within a column followed by the same letter are not significantly different as determined by overlap of 95% FL. Resistance ratios (RR) are calculated in relation to the mean LC_{50} or LC_{90} of site 7 (LC_{50} or LC_{90} of indicated collection/LC_{50} or LC_{90} of site 7).

Mean LC_{50} and LC90 for citrus thrips (average of 8 sites exclusive of Site 7): 1.092 and 3.806 mg [AI]/liter.

Comparison data for avocado thrips:

<u>Conclusion:</u> Comparing the Fallbrook avocado thrips data to the mean values for citrus

Date tested	Site (region)	Slope ± SE	LC_{50} (mg [AI]/liter) (95% FL)	LC_{90} (mg [AI]/liter) (95% FL)	RR $_{50}$	RR_{90}
18/2/98	Fallbrook (Ventura County)	1.61 ± 0.08	0.0342 (0.0267-0.0454)	0.2129 (0.1310-0.4703)	0.043	0.10

thrips, avocado thrips is somewhat more sensitive to spinosad than is citrus thrips (it takes 31.9 (1.092 / 0.0342) and 9.8-fold more chlorfenapyr to kill 50 and 90% of citrus thrips compared with avocado thrips).

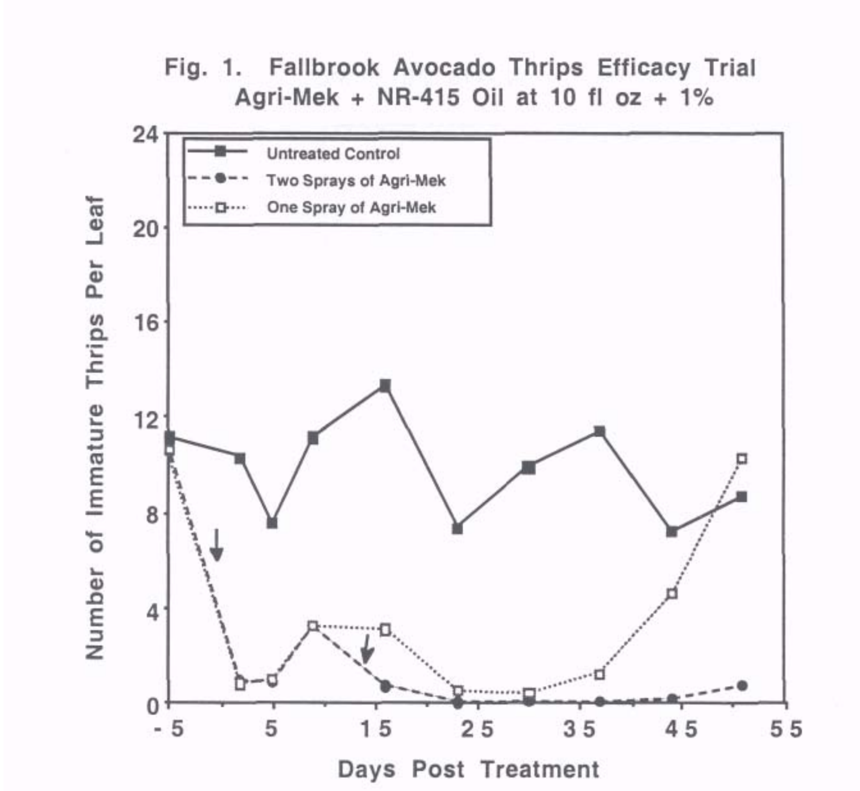
Based on the above data and previous data with cirrus thrips, we expected that spinosad might be an extremely effective material against avocado thrips.

<u>Project 2b</u> Conduct a field avocado thrips pesticide efficacy trial in Fallbrook.

Note: In setting up this trial, we leaned heavily on what was learned in earlier avocado thrips pesticide efficacy trials conducted in Ventura County by P. Phillips and B. Faber.

Data are from: Morse, J. G., M. S. Hoddle, M. Hand, M. Nyberg, A. A. Urena, T. Roberts, and S. Peirce. 1998. Results of a 1998 avocado thrips pesticide efficacy trial near Fallbrook. California Avocado Commission Project Update, December, 1998. 8 pp.

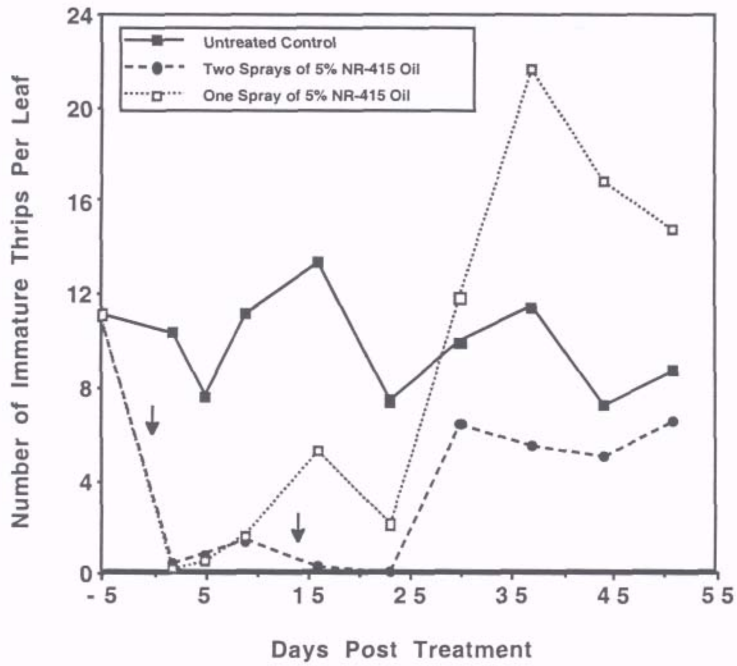
The pesticide trial in Fallbrook compared 1 and 2 treatments of each of 8 chemicals against an untreated control (the above publication lists results of the trial). The most effective treatments were cyfluthrin (Baythroid) followed by abamectin (Agri-Mek) + Oil. Based partially on these data and because of concerns regarding possible resurgence of avocado thrips and other pests following cyfluthrin treatments, abamectin was chosen as the material to submit a Section 18 Emergency Use Request for (Figure 1).



Two other results of the trial are noteworthy. First, spinosad (Success) did not perform as well in the field trial as we expected based on experience on citrus and results of the above bioassays (Project 2a). After some reflection, we think it is likely that oil may need to be added to spinosad in the same way as it is needed for abamectin treatments (both materials are in a class of chemistry called macrocyclic lactones and are subject to photodegradation if they don't penetrate into the plant; oil assists in abamectin penetration and is likely more necessary for penetration into avocado plant tissues than is the case on citrus).

Secondly, the resurgence of avocado thrips populations following oil treatment was surprising (populations resurged to nearly twice the level observed in the untreated control, see Figure 2). The mechanism for this resurgence is not understood and may require further study.

Fig. 2. Fallbrook Efficacy Trial -- NR-415 Oil at 5%



Future Project B — Determine if addition of low rates of Oil aid in the residual persistence of spinosad in control of avocado thrips and what rate of Oil is optimally added to abamectin treatments. A research trial was initiated in Bonsall on Feb. 2, 1999 in which we will evaluate rates of oil from 0.25 - 4% added to both spinosad and abamectin.

Future Project C — Study the impact of Oil on avocado leaf flush and avocado thrips population. Our objective would be to better understand the resurgence of avocado thrips populations following Oil treatment (see the single Oil spray in Figure 2 above). This would be a good graduate student project for a student in the Botany & Plant Sciences Department working cooperatively with an Entomologist.

Future Project D — Evaluate the impact of cyfluthrin on resurgence of avocado thrips and other avocado pests. Based on research on other crops, there is some concern that cyfluthrin may cause pest upsets on avocado (e.g., mite flareups). We would like to ask from volunteers from avocado growers in various regions of California who would be willing to donate 16-64 trees (4x4 to 8x8 block) to a study looking at the impact of a single cyfluthrin treatment on pest populations. The study would continue for ca. 1 year and would require crop destruction because cyfluthrin is not yet registered for use on avocados.

Project 3 Development of bioassay methods for avocado thrips resistance monitoring.

Basic avocado thrips resistance monitoring methods have been adapted from those use for citrus thrips but methods for sabadilla, abamectin, and spinosad required some refinement. Little work was done in the past with sabadilla because until the work of Hare (1996) and Hare & Morse (1997), it was unclear which alkaloids present in sabadilla were responsible for activity against thrips. We now have a standard lot of sabadilla that we will use for all bioassays, Hare has quantified alkaloid levels for the lot, and we will maintain sugar concentration at a constant rate of 13.2 g/ liter.

With both abamectin and spinosad, a number of bioassay were done comparing dip versus spray application to the leaf with and without various rates of oil. After a number of tests, we have settled on spray application without the addition of oil as our standard bioassay method.

Hare, J. D. 1996. Purification and quantitative analysis of veratridine and cevadine by HPLC. J. Agric. Food Chem. 44: 149-152.

Hare, J. D. and J. G. Morse. 1997. Toxicity, persistence, and potency of sabadilla alkaloid formulations to citrus thrips (Thysanoptera: Thripidae). J. Econ. Entomol. 90: 326-332.

Future Project E — Conduct field resistance bioassays with abamectin, chlorfenapyr, cyfluthrin, sabadilla, and spinosad. Ideally, we would like to do bioassays with the following materials and at the following regions in California.

Spinosad:	Already have a good bioassay from Fallbrook	
	99.1	Ventura Co.
	99.2	San Diego Co.
Chlorfenapyr	Already have a good bioassay from Carpinteria	
	99.3	Bonsall
Abamectin	99.4	Bonsall
	99.5	Ventura Co.
	99.6	San Diego Co.
Sabadilla	99.7	Ventura Co. site with low previous sabadilla exposure
	99.8	Bonsall -- low previous sabadilla exposure
	99.10	San Diego Co. -- low previous sabadilla exposure
	99.11	Site with suspected sabadilla resistance
	99.12	Second site with suspected sabadilla resistance
Cyfluthrin	99.13	Bonsall
	99.14	Ventura Co.

<u>Project 4</u> Import *Goetheana incerta* from South Africa and test against avocado thrips.

With the cooperation of Dr. Tim Grout of South Africa, a second attempt was made to import this parasitoid through the UCR Quarantine Facility in May, 1998. On arrival, there appeared to be 55 healthy looking parasitoid pupae, 6 live adults, and 32 dead adults. Dr. Grout confirmed that they probably held the parasitoids too long in South Africa in an attempt to increase the number of parasitoids they could send us. The 6 live adults (tentatively 4 females and 2 males) were tested against bean thrips and it appeared that this host was not recognized or attacked.

The remaining pupae were held in Quarantine for 2 months and checked daily for emergence. Unfortunately, only 1 parasitoid emerged, appeared to be a female, and when tested against avocado thrips, did not appear to recognize the thrips (this should be confirmed — the parasitoid may have been male).

We have contacted Dr. Grout and he plans on sending us a new parasitoid shipment some time within the next several months. A new Ph.D. graduate student, Mr. Ali Al-Wahaib has started on this project.

Future Project F — Import *Goetheana incerta* from South Africa, test it against avocado thrips, develop rearing methods, and release it into the field.

<u>Project 5</u> Evaluate inundative lacewing releases for avocado thrips control.

Ms. Cressida Silvers is working on this project for her M.S. degree. Working with Dr. Mark Hoddle, a lacewing test is being set up at the Irvine Ranch. We will test the following treatments, each applied to 8 single tree replicates.

1. untreated
2. sabadilla applied as needed based on monitoring
3. abamectin followed by sabadilla as needed (possible 2nd abamectin treatment if after 30 days)
4. high level of lacewings released (2,000 / tree); 3 release times - full bloom, fruit set, and when small fruit are present; release as small first instar larvae
5. low level of lacewings released (200 / tree); 3 release times
6. sabadilla and high level of lacewings alternated
7. sabadilla and low level of lacewings alternated
8. abamectin and high level of lacewings alternated
9. abamectin and low level of lacewings alternated
10. lacewings eggs sprayed on tree; 2,000 eggs/tree
11. *Franklinothrips* larvae applied to tree at a high rate

<u>Future Project G</u> — Conduct above lacewing trial (recently initiated

<u>Future Project H</u> — Evaluate entomophagous nematodes for possible use against avocado thrips. Dr. Kirk Smith was funded by the Hansen Board to conduct this research. He has contacted us to cooperate on bioassays by providing late second instar thrips. Since we don't have an avocado thrips colony, we will use citrus thrips in these tests.

<u>Project 6</u> Conduct persea mite pesticide efficacy trials.

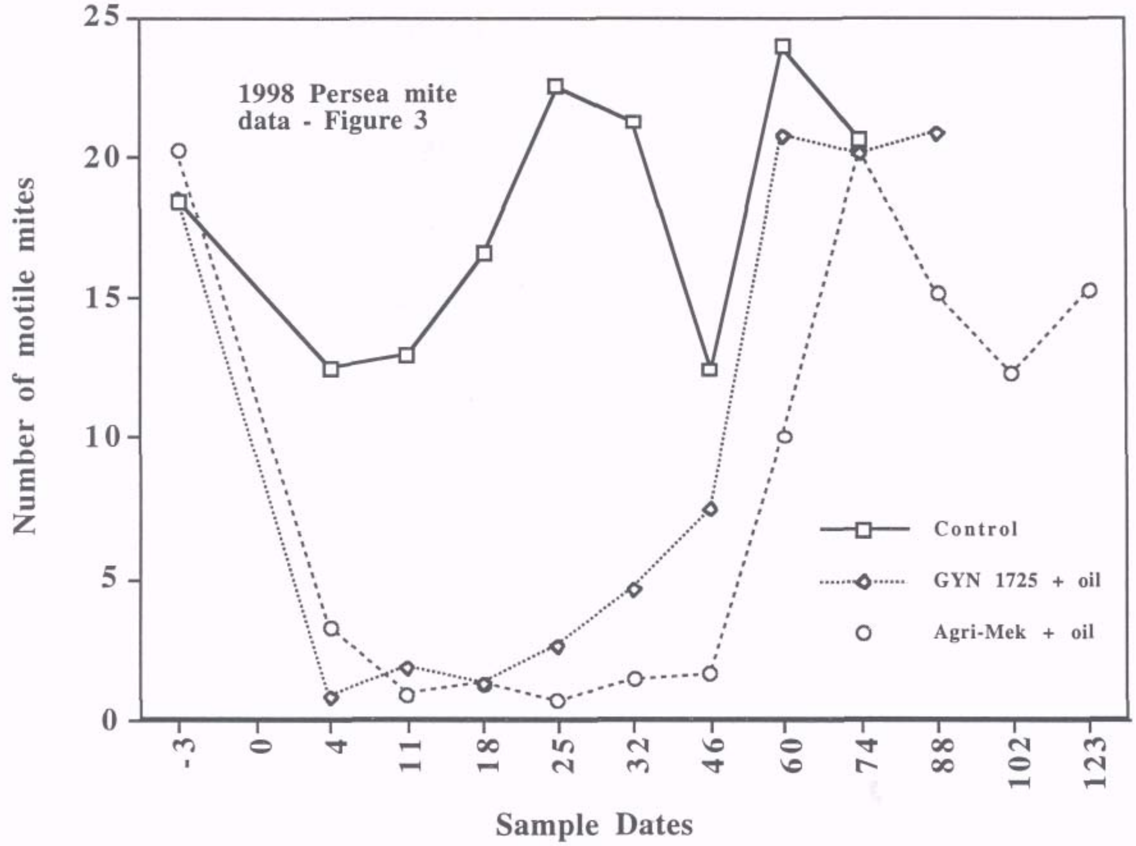
A test was conducted at the Irvine Ranch with the assistance of Mark Hoddle, Matt Hand, Mark Nyberg, and Tom Roberts. An avocado block with high persea mite levels was chosen, precounts were taken, and trees were assigned to treatments based on the precounts. Each treatment was replicated on 8 trees and 10 leaves per tree were counted each sample date using the half second vein method developed by Dave Machlitt. Treatments were applied on July

24 using a model SR-400 Pacific Stihl low-volume backpack mist sprayer.

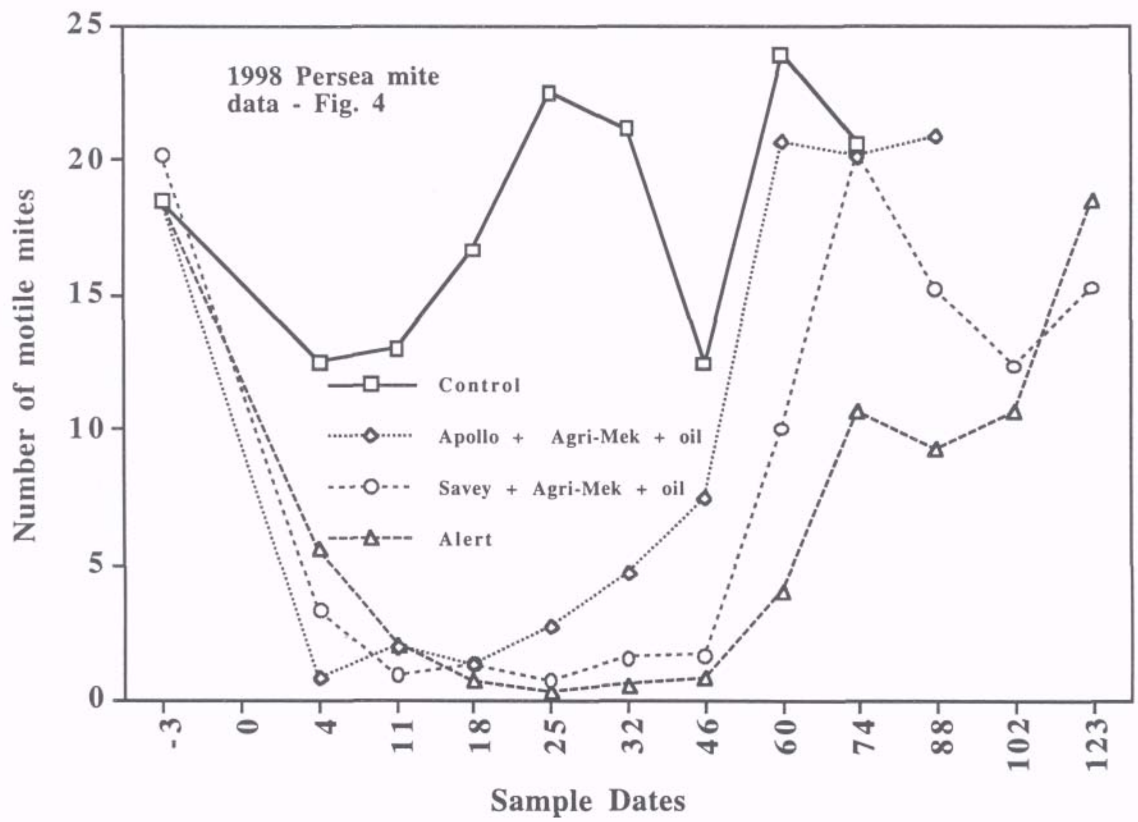
We reviewed mite pesticide trials run on other crops (all tests reported in the 1998 issue of Arthropod Management Tests and decided on the following 9 treatments:

1. water control
2. Nexter 75 WP at 10.67 oz / acre
3. Apollo 42 SC (ovicidal activity only) +Agri-Mek 0.15 EC + NR 515 Oil at 8 fl oz / acre + 10 fl oz / acre + 1%
4. Savey 50 WP (ovicidal activity only) +Agri-Mek 0.15 EC + Oil at 6 fl oz / acre + 10 fl oz / acre + 1%
5. Alert 2 EC at 0.25 lb ai/ acre
6. OWN 1725 1% EC + Oil at 20 fl oz / acre + 1%
7. Agri-Mek 0.15 EC + Oil at 10 fl oz / acre + 1%
8. Oil at 1%
9. UC-D2341 50 WP at 1 lb ai/ acre

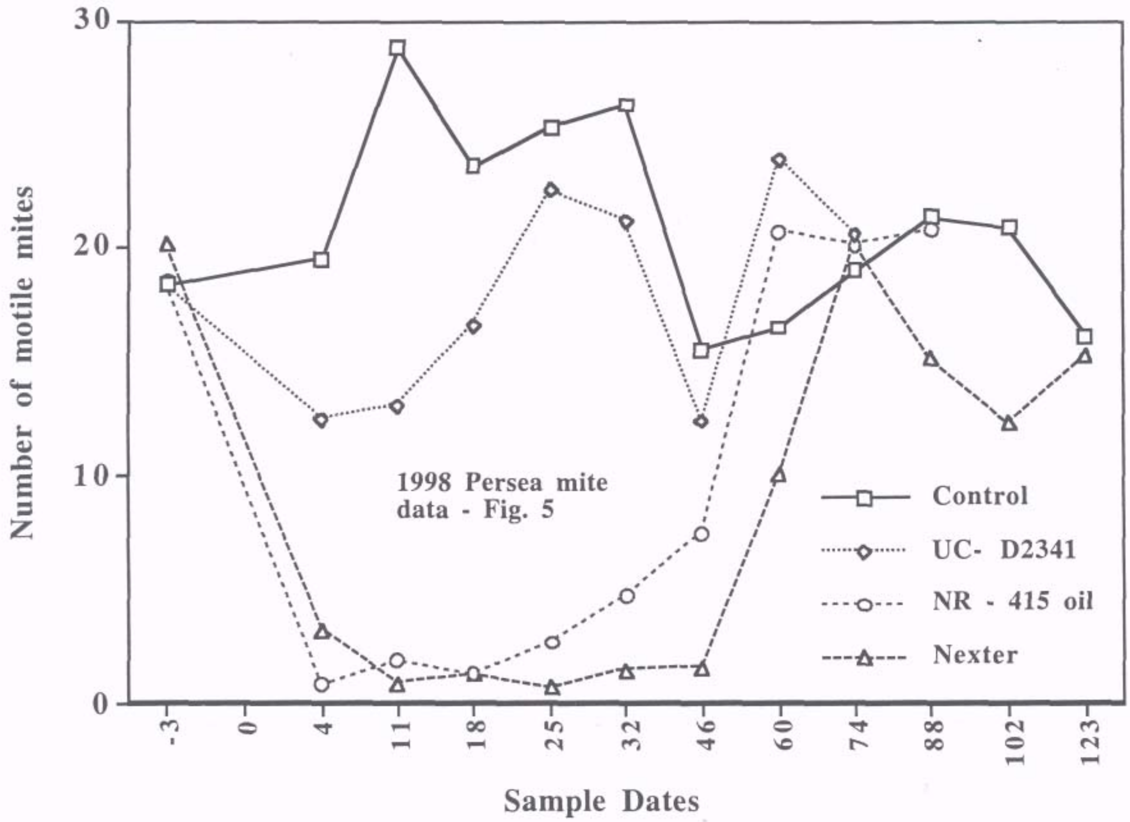
Mite counts are shown below in relation to the untreated control. As can be seen, the only ineffective material was UC-D2341.



1998 Persea mite data - Figure 3
Number of motile mites
Sample Dates
0
5
10
15
20
25
-3
0
4
11
18
25
32
46
60
74
88
102
123
Control
GYN 1725 + oil
Agri-Mek + oil



1998 Persea mite data - Fig. 4
Number of motile mites
Sample Dates
0
5
10
15
20
25
-3
0
4
11
18
25
32
46
60
74
88
102
123
Control
Apollo + Agri-Mek + oil
Savey + Agri-Mek + oil
Alert



30
20
10
0
Number of motile mites
1998 Persea mite
data - Fig. 5
Control
UC- D2341
NR - 415 oil
Nexter
-3
0
4
11
18
25
32
46
60
74
88
102
123
Sample Dates