Project Number: 95-C1

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Annual Report to
Almond Board of California
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Insect and Mite Research

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Cooperators: UC Cooperative Extension Farm Advisors in 8 counties for Objective 1; Walt Bentley, Bill Krueger, Carolyn Pickel and Dr. Michael Stimmann (Dept. of Environmental Toxicology) for Objective 2.

Objectives:

1. Purchase pheromone traps and lures, and other monitoring supplies for Farm Advisors as part of their ongoing monitoring efforts.

2. Conduct a field trial in both the San Joaquin Valley and the Sacramento Valley to test the effect of esfenvalerate, permethrin, and organophosphate dormant sprays and in-season sprays on peach twig borer and non-target species including mites.

Background and Summary:

Objective 1. This project has been a cooperative effort with many UC Extension Farm Advisors over the years. It has focused on the development and implementation of tools for managing pesticides in a judicious manner, and on the development and use of non chemical alternatives. The use of pheromone traps and degree-day phenology models has become fairly common in the industry, but it is possible that the techniques can be misused or that the materials used are not effective in some instances. Trapping supplies are purchased each year for use by participating UC Farm Advisors to help confirm the accuracy of the techniques, and to help them to monitor activity of specific insects in their counties. The trapping records are assembled at UC Davis at the end of each season. The actual cost of supplies purchased for this purpose in 1995 was about $3,600.

Objective 2. Several mite species have the potential to cause economic damage in orchards. Of special concern are the web-spinning mites which include both the two-spotted and Pacific spider mites. Two other spider mite species, the European red and the brown almond mite are occasionally present in large numbers. The latter species are adequately controlled by a dormant spray with sufficient rates of superior type oil, and typically should not require in-season treatments. Mites can be chronic problems for growers in some areas of California - even when predatory mites are present - when conditions such as dust or water-stress are favorable for development. However, often they are a result of secondary outbreaks, referring to the build-up of mites previously controlled by natural enemies or somehow induced physiologically or behaviorally. Spraying for key pests such as peach twig borer or navel orangeworm with certain non-selective materials can cause secondary outbreaks of mites. If not carefully monitored and treated, spider mites can defoliate trees and reduce the following season's growth and yield.

Many almond growers had reported mite outbreaks in 1993 and 1994. Although the extended draught or other factors might have been responsible for this observation, the possibility that these may have been secondary outbreaks resulting from increased use of pyrethroid insecticides could not be discounted. Some growers are choosing to use pyrethroids - either permethrin (Pounce or Ambush) or esfenvalerate (Asana) - in the dormant season as an alternative to organophosphate insecticides for control of peach twig borer and scale insects even though it continues to be possible to use several organophosphates and *Bacillus thuringiensis* (for peach twig borer) which we have shown does not induce secondary pest problems in several years of research and demonstration. Other growers are choosing to apply the pyrethroids in-season for other insect pests instead of more costly treatments.

The scientific literature implicates in-season applications of both permethrin and fenvalerate (Pydrin) with such outbreaks in apple and grape systems, and attributes the mechanism to killing mite predators, dispersing the mites on the tree to create more mite colonies, or some other yet unknown factor. Permethrin applications in almond orchards were shown to induce spider mite outbreaks the following season in a published study by Bentley, Zalom and John Sanderson in 1987. Pyrethroids can be very stable compounds, so it is not surprising that such results might occur.

Both permethrin (Pounce or Ambush) and esfenvalerate (Asana) are being used as dormant sprays, but it is not known if they can be used without inducing secondary pest problems at that time or how long their residues will persist on twigs. Similarly, it is not known if esfenvalerate can be used during the growing season without inducing secondary outbreaks. This study was designed to test the effect of esfenvalerate, permethrin, and organophosphate dormant sprays and in-season sprays on peach twig borer and non-target species including mites.

Methods:

Small and large plots were established in almond orchards in Glenn and Fresno counties, and in peach and prune orchards in the Sacramento Valley. Treatments in the small plots were applied by handgun to single trees with buffer trees around each treated tree in eight replicated complete blocks. Dormant sprays were applied 3 February, 1995, and hull split sprays on 21 July, 1995. Treatments consisted of:

1. Asana (Dormant)
2. Ambush (Dormant)
3. Organophosphate (Dormant)
4. Untreated
5. Asana (Dormant) + Asana (Hull split)
6. Ambush (Dormant) + Ambush (Hull split)
7. Asana (Dormant) + Asana+Vendex (Hull split)
8. Ambush (Dormant) + Ambush+Vendex (Hull split)

Sampling was conducted monthly for spider mites and mite predators. Cardboard bands were placed around all trees in each treatment before larval emergence, and removed before adult emergence to determine peach twig borer abundance. No subsequent treatments were made in these plots. Twigs were cut from trees in the esfenvalerate, permethrin and control treatments at various times during the year, and residue analysis performed. A laboratory experiment was conducted late in the summer to determine effect of residues remaining on the twigs on the western orchard predator mite. Predator mites were placed on 2 cm long pieces of twig, and mortality evaluated. We intend to repeat this laboratory experiment again in January during this dormant season, and we will sample these same trees the following season for spider mites and predators.

Treatments in the large plots were applied by orchard sprayer to plots 8 trees by 16 trees in size and with 3 replicates. Dormant sprays were applied on 3 February, 1995. Bt bloom sprays were applied both at popcorn and petalfall. Hull split sprays were applied on 12 July, 1995. Treatments consisted of:

1. Asana+Oil (Dormant)
2. Ambush+Oil (Dormant)
3. *Bacillus thuringiensis* (Bloom, 2 times)
4. Untreated+Oil (Dormant)
5. Bt (Bloom, 2 times) + Asana (Hull split)
6. Bt (Bloom, 2 times) + Ambush (Hull split)
7. Guthion (Hull split)

Six trees from the center of each plot were sampled each month for spider mites and predators. Nuts or fruit were harvested from the center of each plot, and cracked to determine damage.

Extraction and analysis for pyrethroids on twig samples was conducted using field collected twigs which were stored at -21C in clean mason jars. The twigs were thawed, and cut into sections about 2 cm long chosen from the internodal portion of the twigs to enable more accurate determination of surface area than is possible with buds and nodes. Each was then immersed in hexane, then placed in a sonic dismembrator and sonicated for 2 minutes to extract the pyrethroids from the plant cuticle. The extracted material was cleaned using solid phase extraction (SPE) chromatography, yielding samples that are almost free of unwanted chemicals such as other pesticides, oils, and waxes. An HP Gas Chromatograph equipped with a robotic autosampler was used for analysis. The entire cleanup and analysis process involved about 20 separate steps, and one technician could analyze 30-40 samples per week. Permethrin and esfenvalerate residues could be detected at levels as low as 0.1 ng/mm sq of bark surface.

Results:

Peach twig borer populations were relatively low, but the results of the small plots trial indicated significant differences in efficacy against overwintering peach twig borers between treatments. No differences were observed between treatments in numbers of spiders which overwintered in the tree bands. The following table indicates the number of peach twig borers and spiders per tree band on almonds removed 14 March, 1995.

	Peach twig borers a/	Spiders b/
Asana (D)	0.04±0.03 ab	0.07±0.03
Ambush (D)	0.03±0.02 a	0.03±0.02
Diazinon (D)	0.20±0.11 bc	0.07±0.03
Untreated (D)	0.21+0.10 c	0.03+0.02

a/ F=3.285, df=3. Means followed by the same letter do not differ at $p<0.05$ by Fisher's Protected LSD.
b/ F=0.92, df=3, $p>0.05$. Salticids and Theridiids.
c/ 8 replicates per treatment.

Both pyrethroids were similar in activity, but the efficacy of diazinon was very disappointing. Similar results were obtained in our trials on the other tree crops, with results from only one prune orchard indicating satisfactory control with diazinon. We do not know the reason for this, but it is possible that pest resistance or the wet weather both preceding and immediately after applications were applied were at fault. We hope to pursue work on this next year.

Predator mite and spider mite populations remained very low throughout the season in the plots in both the Glenn and Fresno County orchards, and differences between treatments in numbers of predator mites, spider mites or European red mites were seldom seen on any sampling date, even after in season sprays were applied. The following tables illustrate this. Not all of the data obtained are presented here, but the early season subsets of the data shown illustrate the lack of mite pressure observed in the field.

Mean (±SE) predatory mites per almond leaf on 13 June, 1995

	Motiles a/	Eggs b/
Asana (D)	0.00±0.00 a	0.00±0.00
Ambush (D)	0.02±0.01 ab	0.02±0.02
Diazinon (D)	0.05±0.02 b	0.02±0.02
Untreated (D)	0.00+0.00 a	0.02+ 0.01

a/ F=3.11, df=3, $p<0.05$. Means followed by the same letter do not differ at<0.05 by Fisher's Protected LSD.
b/ F=0.68, df=3, $p>0.05$.

Mean (±SE) European red mites per leaf on 13 June, 1995.

	Motiles a/	Eggs b/
Asana (D)	0.01±0.01	0.00±0.00
Ambush (D)	0.01±0.01	0.04±0.03
Diazinon (D)	0.11±0.08	0.01±0.01
Untreated (D)	0.00+0.00	0.01+0.01

a/ F=1.49, df=3, p>0.05.

b/ F=1.01, df=3, p>0.05.

Mean (±SE) spider mites per almond leaf on 13 June, 1995.

	Motiles a/	Eggs b/
Asana (D)	0.01±0.01	0.01±0.01
Ambush (D)	0.01±0.01	0.10±0.06
Diazinon (D)	0.00±0.00	0.04±0.04
Untreated (D)	0.00+0.00	0.00+0.00

a/ F=0.667, df=3, p>0.05.

b/ F=1.468, df=3, p>0.05.

c/ 15 leaves/tree brushed, 8 trees/treatment.

Mean (±SE) predatory mites per leaf on 21 July, 1995.

	Motiles a/	Eggs b/
Asana (D)	0.00±0.00	0.01±0.01
Ambush (D)	0.00±0.00	0.00±0.00
Diazinon (D)	0.00±0.00	0.01±0.01
Untreated (D)	0.00+0.00	0.00+0.00

a/ F=0.000, df=3, p>0.05.

b/ F=0.67, df=3, p>0.05.

Mean (±SE) European red mites per leaf on 21 July, 1995.

	Motiles a/	Eggs b/
Asana (D)	0.00±0.00	0.01±0.01
Ambush (D)	0.17±0.11	0.71±0.37
Diazinon (D)	0.05±0.03	0.22±0.11
Untreated (D)	0.02+0.01	0.41+0.10

a/ F=1.936, df=3, p=0.1486.

b/ F=2.223, df=3, p=0.1075.

Mean (±SE) spider mites per leaf on 21 July, 1995.

	Motiles [a/]	Eggs [b/]
Asana (D)	0.00±0.00 a	0.01±0.01
Ambush (D)	0.19±0.07 b	0.45±0.25
Diazinon (D)	0.03±0.19 a	0.19±0.08
Untreated (D)	0.23+0.07 b	0.29+0.07

a/ F=4.812, df=3, p<0.01. Means followed by the same letter do not differ at p<0.05 by Fisher's Protected LSD.
b/ F=1.814, df=3, p=0.1675.

Mean (±SE) predatory mites per leaf on 25 September, 1995.

	Motiles [a/]	Eggs [b/]
Asana (D)	0.76±0.21	0.17±0.06
Ambush (D)	0.21±0.05	0.00±0.00
Diazinon (D)	0.10±0.28	0.01±0.01
Untreated (D)	0.61±0.22	0.11±0.05
Asana(D)+Asana(HS)	0.66±0.27	0.05±0.03
Ambush(D)+Ambush(HS)	0.41±0.13	0.07±0.04
Asana(D)+As&Ven(HS)	0.47±0.15	0.12±0.05
Ambush(D)+Amb&Ven(HS)	0.32+0.11	0.18+0.10

a/ F=1.877, df=3, p>0.05.
b/ F=1.745, df=3, p>0.05.

Mean (±SE) European red mites per leaf on 25 September, 1995.

	Motiles [a/]	Eggs [b/]
Asana (D)	0.56±0.30	0.97±0.22
Ambush (D)	0.38±0.08	0.68±0.22
Diazinon (D)	0.27±0.06	0.86±0.13
Untreated (D)	0.60±0.18	1.07±0.26
Asana(D)+Asana(HS)	0.52±0.17	1.09±0.23
Ambush(D)+Ambush(HS)	0.71±0.11	1.18±0.20
Asana(D)+As&Ven(HS)	0.47±0.16	0.72±0.33
Ambush(D)+Amb&Ven(HS)	0.11+0.44	0.58+0.11

a/ F=1.449, df=3, p>0.05.
b/ F=1.072, df=3, p>0.05.

Mean (±SE) spider mites per leaf on 25 September, 1995.

	Motiles [a/]	Eggs [b/]
Asana (D)	1.45±0.74 ab	1.21±0.26 a
Ambush (D)	1.02±0.22 ab	0.93±0.22 a
Diazinon (D)	4.92±2.30 c	4.04±0.96 b
Untreated (D)	3.35±0.86 bc	1.74±0.26 a
Asana(D)+Asana(HS)	1.52±0.53 ab	1.38±0.27 a
Ambush(D)+Ambush(HS)	1.02±0.11 ab	1.17±0.24 a
Asana(D)+As&Ven(HS)	2.32±0.50 abc	1.81±0.32 a
Ambush(D)+Amb&Ven(HS)	0.47±0.12 a	0.67±0.12 a

a/ F=2.339, df=3, p<0.05. Means followed by the same letter do not differ at p<0.05 by Fisher's Protected LSD.

b/ F=3.135, df=3, p<0.01. Means followed by the same letter do not differ at p<0.05 by Fisher's Protected LSD.

As in the small plots, number of peach twig borers, and mites were low in the large plots. Differences between treatments in numbers of predator mites, spider mites or European red mites were seldom seen on any sampling date, even after in season sprays were applied. Any differences on the last sampling date were probably due to factors other than treatment. No difference in peach twig borer efficacy between treatments was observed because of the low abundance. A significant reduction in overwintering spider abundance was observed in the Asana treated plots. Lower, but not significant, abundance in general predators was observed in the pyrethroid treated plots in season. The following tables illustrate this.

Number of peach twig borers and spiders per tree band on almonds, 14 March, 1995.

	Peach twig borers [a/]	Spiders [b/]
Asana+Oil (D)	0.00±0.00	0.06±0.06 a
Ambush+Oil (D)	0.00±0.00	1.07±0.34 b
Untreated+Oil (D)	0.00±0.00	1.07±0.43 b
Bt (B)	0.04±0.04	1.18±0.30 b

a/ F=0.000, df=3, p>0.05.

b/ F=3.448, df=3, p<0.05. Means followed by the same letter do not differ at p<0.05 by Fisher's Protected LSD. Salticids and Theridiids.

Number of spiders and beneficial insects per 3-beat sample on almonds, 5 June, 1995.

	Spiders [a/]	Beneficials [b/]
Asana+Oil (D)	0.06±0.06	0.56±0.56
Ambush+Oil (D)	0.06±0.06	0.22±0.13
Untreated+Oil (D)	0.17±0.09	0.28±0.11
Bt (B)	0.22±0.10	0.28±0.16

a/ F=1.113, df=3, p>0.05. primarily Salticids & Theridiids.

b/ F=0.738, df=3, p>0.05. Mean (±SE) total parasitoids, lacewing larvae, lady beetles, assassin bugs, and damsel bugs per sample.

Mean (±SE) predatory mites per almond leaf on 9 May, 1995.

	Motiles [a/]	Eggs [b/]
Asana+Oil (D)	0.00±0.00 a	0.00±0.00
Ambush+Oil (D)	0.00±0.00 a	0.00±0.00
Untreated+Oil (D)	0.00±0.00 a	0.00±0.00
Bt (B)	0.17±0.09 b	0.00±0.00

a/ $F=3.400$, $df=3$, $p<0.05$. Means followed by the same letter do not differ at $p<0.05$ by Fisher's Protected LSD.
b/ $F=0.00$, $df=3$, $p>0.05$.

Mean (±SE) predatory mites per almond leaf on 13 June, 1995.

	Motiles [a/]	Eggs [b/]
Asana+Oil (D)	0.01±0.01 a	0.07±0.02
Ambush+Oil (D)	0.01±0.01 a	0.07±0.03
Untreated+Oil (D)	0.08±0.02 b	0.07±0.02
Bt (B)	0.03±0.01 a	0.09±0.03

a/ $F=6.053$, $df=3$, $p<0.05$. Means followed by the same letter do not differ at $p<0.05$ by Fisher's Protected LSD.
b/ $F=0.349$, $df=3$, $p>0.05$.

Mean (±SE) European red mites per leaf on 13 June, 1995.

	Motiles [a/]	Eggs [b/]
Asana+Oil (D)	0.01±0.01	0.12±0.05
Ambush+Oil (D)	0.02±0.01	0.04±0.02
Untreated+Oil (D)	0.06±0.02	0.04±0.02
Bt (B)	0.06±0.02	0.04±0.02

a/ $F=0.085$, $df=3$, $p>0.05$.
b/ $F=2.035$, $df=3$, $p=0.1194$.

Mean (±SE) spider mites per almond leaf on 13 June, 1995.

	Motiles [a/]	Eggs [b/]
Asana+Oil (D)	0.02±0.01 a	0.01±0.01
Ambush+Oil (D)	0.06±0.03 a	0.04±0.02
Untreated+Oil (D)	0.17±0.05 b	0.05±0.02
Bt (B)	0.08±0.02 a	0.05±0.02

a/ $F=3.339$, $df=3$, $p<0.05$. Means followed by the same letter do not differ at $p<0.05$ by Fisher's Protected LSD.
b/ $F=1.060$, $df=3$, $p>0.05$.

Mean (±SE) predatory mites per almond leaf on 21 July, 1995.

	Motiles [a/]	Eggs [b/]
Asana+Oil (D)	0.012±0.012	0.006±0.006 ab
Ambush+Oil (D)	0.015±0.007	0.007±0.007 ab
Untreated+Oil (D)	0.017±0.012	0.045±0.019 bc
Bt (B)	0.055±0.029	0.011±0.008 ab
Bt (B)+Asana (HS)	0.070±0.049	0.000±0.000 a
Bt (B)+Ambush (HS)	0.019±0.011	0.011±0.006 ab
Guthion (HS)	0.023±0.019	0.047±0.023 c

a/ F=0.749, df=3, $p>0.05$.
b/ F=2.426, df=3, $p<0.05$. Means followed by the same letter do not differ at $p<0.05$ by Fisher's Protected LSD.

Mean (±SE) European red mites per leaf on 21 July, 1995.

	Motiles [a/]	Eggs [b/]
Asana+Oil (D)	0.00±0.00	0.00±0.00
Ambush+Oil (D)	0.00±0.00	0.01±0.01
Untreated+Oil (D)	0.00±0.00	0.01±0.01
Bt (B)	0.00±0.00	0.00±0.00
Bt (B)+Asana (HS)	0.00±0.00	0.01±0.01
Bt (B)+Ambush (HS)	0.00±0.00	0.01±0.01
Guthion (HS)	0.00±0.00	0.01±0.01

a/ F=0.000, df=3, $p>0.05$.
b/ F=0.668, df=3, $p>0.05$.

Mean (±SE) spider mites per almond leaf on 21 July., 1995.

	Motiles [a/]	Eggs [b/]
Asana+Oil (D)	0.03±0.02	0.00±0.00
Ambush+Oil (D)	0.07±0.02	0.07±0.07
Untreated+Oil (D)	0.05±0.02	0.00±0.00
Bt (B)	0.05±0.02	0.04±0.03
Bt (B) + Asana (HS)	0.23±0.13	0.23±0.11
Bt (B) + Ambush (HS)	0.00±0.00	0.02±0.02
Guthion (HS)	0.06±0.03	0.07±0.04

a/ F=1.546, df=3, $p>0.05$.
b/ F=1.658, df=3, $p>0.05$.

Twig samples were taken from the almond, peach and prune plots after the dormant treatment, during the spring just after tree bands were removed from the plots, and after the hullsplit (in almonds) or summer cover sprays (peaches and prunes) were applied, and subjected to residue analysis. Dormant twig samples will be collected in all plots prior to the application of dormant sprays this season. Sampling dates for pyrethroid residue analysis were as follows:

		Almonds	
Peaches	Prunes	Glenn Co.	Fresno Co.
2 February	16 February	3 February	--
4 April	28 April	14 April	--
24 July	12 July	21 July	--
--	--	24 August	--
Dormant	Dormant	Dormant	Dormant

Residue analysis has not been completed on all of the samples, but some interesting results have been obtained to date which suggest that continued study of these plots is needed. We had proposed taking far fewer residue samples because of the potential expense of sending samples to a commercial laboratory. Dr. Michael Stimmann in the Department of Environmental Toxicology developed a method of extracting the residues which proved relatively inexpensive, permitting more thorough analysis. The extraction efficiency for the pyrethroid analysis using sonification extraction is as follows:

	ppb in extraction solution			
Pesticide	Permethrin			Percent
Tissue	*cis-*	*trans-*	Esfenvalerate	extracted
Permethrin				
Whole twig	4212	5481	174	92
Whole twig	5327	6792	258	94
Bark	409	447	0	
Bark	363	428	0	
Wood	0	0	0	
Wood	Tr	Tr	0	
Esfenvalerate				
Whole twig	0	0	9878	95
Whole twig	0	0	8733	94
Bark	0	0	426	
Bark	0	0	493	
Wood	0	0	78	
Wood	0	0	66	

These results were very good as extraction techniques rarely remove 100% of the pesticide residue, especially if its bound in the plant's waxes or oils. Sonification in organic solvents is particularly efficient. Extraction efficiency was determined by grinding the bark and wood remaining after signification and extraction of the whole twig, then reanalyzing. Over 90% extraction was achieved.

We then determined whether the pyrethroid residues were located on bark and/or woody tissue. Location of residues on and within the twigs is important as only the residues that would be exposed to organisms should have biological activity. The following table gives the results of this analysis.

Pesticide Tissue	ppb in extraction solution Permethrin *cis-*	*trans-*	Esfenvalerate
Permethrin			
Bark	2928	2426	117
Bark	2260	2626	110
Wood	128	95	0
Wood	Tr	Tr	0
Esfenvalerate			
Bark	0	0	141
Bark	0	0	160
Wood	0	0	0
Wood	0	0	0

These data show that the residues are almost exclusively associated with the bark, and therefore the surface of the twig. Penetration of the material into the wood does not appear to be a problem. We then attempted to determine the amount of pyrethroid residues in relation to location on twig, and obtained the following data.

Pesticide and Twig part	Pesticide residue on bark (ng/mm^2) a/ Permethrin *cis-*	*trans-*	Esfenvalerate
Permethrin			
Internode	0.76	1.07	0.056
Internode	0.99	1.37	0.056
Node/bud	1.55	2.11	0.058
Node/bud	2.02	2.78	0.081
Esfenvalerate			
Internode	0.00	0.00	1.41
Internode	0.00	0.00	5.98
Node/bud	0.00	0.00	6.30
Node/bud	0.00	0.00	4.71

a/ We could not accurately estimate bud surface area, therefore node/bud values overestimate ng/mm^2.

These results indicate that there appears to be some difference in residue between node and internode parts of twigs. However, because the node (bud) parts of twigs probably have more surface area, it is difficult to accurately determine the surface area, and therefore to make comparisons. If greater concentration of residue is present in the node (bud) parts, predator mites (which overwinter in this region) could have greater exposure to the residue.

We then attempted to determine whether the pyrethroid residues could easily be washed from bark, as might occur during rain events in winter following the dormant application. Pyrethroid residues washed from bark were as follows:

Treatment Solvent	ppb in extraction solution Permethrin *cis-*	*trans-*	Esfenvalerate
Control twig			
Water	0	0	0
Water+Surf.	0	0	0
Hexane	0	0	0
Spiked twig			
Water	0	0	0
Water+Surf.	90	127	116
Hexane	175	207	262
Permethrin			
Water	0	0	0
Water+Surf.	417	626	0
Hexane	3054	3847	80
Esfenvalerate			
Water	0	0	43
Water+Surf.	0	0	200
Hexane	0	0	3853

In general, pesticides may be extracted with either water alone, water plus a surfactant, or with an organic solvent. Pyrethroid extraction from twigs in this study required an organic solvent. From these data we can assume that water does not remove significant amounts of the pyrethroids from twigs, and therefore that rainfall including the record amounts obtained this past year would not remove all residue.

Ultimately we hope to be able to determine the breakdown rate and longevity of the pyrethroid residues on the bark of almond twigs, and we will have this data once all residue tests have been completed and summarized. Some indication of the longevity of the pyrethroid residues on almond twigs is shown on the following graph which indicates residues present on 24 August, 1995, from applications applied at either dormant (D) or dormant and hullsplit (HS) timings.

Pesticide and timing	Pesticide residue on bark (ng/mm^2) [a/] Permethrin *cis-*	*trans-*	Esfenvalerate
Untreated	0.0000	0.0000	0.0000
Asana (D)	0.0000	0.0000	0.1588
Ambush (D)	0.1613	0.2475	0.0030
Asana (D) + Asana (HS)	0.0000	0.0000	0.3038
Ambush (D) + Ambush (HS)	0.3263	0.4700	0.0080
Asana (HS)	0.0000	0.0000	0.2213

[a/] Mean of 8 samples.

We performed a bioassay using the predatory mite, *Galandromus (=Metaseiulus) occidentalis*, to determine survival on the almond twigs collected on 24 August, 1995, for which residue tests were also obtained. The following is a summary table of those results.

Pesticide and timing [b]	Percent survival corrected for control mortality [a] 24 hrs [c]		Percent survival corrected for control mortality [a] 48 hrs [d]	
Untreated	100.0	d	100.0	d
Asana (D)	19.6	a	8.4	ab
Ambush (D)	53.6	c	48.1	c
Asana (D) + Asana (HS)	61.6	c	33.7	bc
Ambush (D) + Ambush (HS)	51.8	c	39.7	c
Asana (HS)	45.5	c	43.3	c
Ambush (HS)	50.9	c	48.1	c
Asana (N)	28.6	ab	6.0	a
Ambush (N)	42.9	bc	44.6	c

a/ 2 mites on each of twigs per dish, 4 dishes per replicate (40 mites total), with 4 replicates of each treatment.
b/ (D)=sprayed 3 February, (HS)=sprayed 21 July, (N)=2 day old residue.
c/ $F=8.851$, $df=8$, $P<0.0001$.
d/ $F=8.355$, $df=8$, $P<0.0001$.

These results indicate the amount of both permethrin and esfenvalerate residues present on almond twigs were sufficient to kill the predatory mites placed on the bark for as much as 7 months after application, even when the treatments were applied as a dormant spray. Since predatory mites often overwinter on the bark of trees, these results indicate that pyrethroid residues can affect overwintering predator populations. We are in the process of repeating this experiment with the same twigs that were collected and frozen following their 24 August collections from the field, and we will repeat this experiment in the dormant season when samples are obtained.

Summary:

The pyrethroid insecticides permethrin and esfenvalerate provide an effective option for control of overwintering peach twig borer in almond orchards. Our field results in 1995 suggest that the pyrethroid dormant sprays may effect generalist predators, but the impact of this on pest populations is unknown. Spider mites were rarely a problem in 1995, and we did not have sufficient populations in our plots to assess the effect, if any, of the pyrethroid sprays on spider mite abundance.

Our laboratory studies indicate that both pyrethroids tested remain on the bark for a long time, and are not easily removed by water (and presumably rainfall). The residues present for up to seven months are capable of killing 50% or more predator mite present on the bark.