Annual Report to
Almond Board of California
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Correct Project Number: 98-FZ-o0
Project No.: 98-FZ-00 Insect and Mite Research

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Project Participants: UC Farm Advisors in 10 counties for Objective 1; James Brazzle (Kern Co.) for Objective 2; James Brazzle (Kern Co.), Doug Walsh (UC Davis) and Barat Bisabri (DowElanco) for Objective 3; Walt Bentley and Mario Viveros (Kern Co.) for Objective 4.

Objectives:

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

2. Conduct field trials to test the effect of several registered materials and new candidate materials as dormant sprays for control of San Jose scale and peach twig borer, and to monitor specific orchards in Kern Co. to determine the possible influence of different pest management practices on San Jose scale and parasite population dynamics.

3. Monitor peach twig borer populations in the San Joaquin and Sacramento Valleys for to determine if differences in susceptibility to organophosphate and pyrethroid insecticides occurs, and to determine baseline susceptibility for the newly registered product spinosad.

4. Support the ongoing Kern County BIOS efforts being conducted by Walt Bentley and Mario Viveros.

Summary of Results:
Objective 1. This objective has been a cooperative effort with many UC Cooperative Extension Farm Advisors over the years. Trapping supplies are purchased each year for use by participating Farm Advisors to help confirm the accuracy of the techniques, and to help them to monitor the activity of specific insects in their counties. The advisors use the data gathered from these traps to update local growers and PCA's in the status of various almond insect pests in their counties,

and in their applied research programs. Much of this data is reported at Almond PMA meetings and BIOS meetings as well. The trapping records are assembled at UC Davis at the end of each season, and have been used for validations of phenology models for navel orangeworm, peach twig borer and San Jose scale. This year over 1500 traps and over 1700 pheromone lures (plus 17 pounds of almond press cake bait) were purchased and distributed to 11 Farm Advisors to monitor navel orangeworm, peach twig borer, San Jose scale, and oriental fruit moth in almond orchards. The total cost of these supplies for 1998 was about $5365.00.

Table 1. Trapping supplies purchased for monitoring insect pests in almonds, 1998.

Name	Location	Wing Traps	Trap Liners	NOW Traps	SJS Traps	PTB Lures	OFM Lures	SJS Lures	NOW Bait (lb)
J. Connell	Butte Co.	6	20			20			
R. Duncan	Stanislaus	6	20	5		50	33		1
R. Coviello	Fresno Co.				8	50		40	
L. Hendricks	Merced Co.	50	100		200	200		200	10
J. Edstrom	Colusa Co.	6	18	4	4	20	10		1
R. Buchner	Tehama Co.	8	64	4	4	32	32	12	1
J. Brazzle	Kern Co.				500			425	
W. Bentley	UC KAC	25	75	50	50	125	0	100	
W. Krueger	Glenn Co.	4	12	4		20			1
W. Reil	Yolo Co.		100	10		75			2
M. Freeman	Fresno Co.	12	48	12	60	120		60	1
F. Zalom	UC Davis	12	36			90			
Total	All Sites	129	493	89	826	802	75	837	17

Objective 2: San Jose scale control and population dynamics. San Jose Scale (SJS) has become an increasing problem for almond growers in the southern San Joaquin Valley. In an effort to better understand this problem Walt Bentley and James Brazzle began to monitor orchards throughout Kern County in 1997, and this monitoring has continued in 1998. Sticky traps baited with the female pheromone of SJS and placed in the orchards in late February were used for monitoring. The traps have been checked on a weekly basis to determine the total number of male SJS and the parasitic wasps *Encarsia* (previously identified as *Prospaltella*) sp. and *Aphytis* sp. Nine orchards continue to be monitored, and these are listed on Table 2 below. History of pesticides used in these orchards has also been determined.

The 1997 data set confirmed the importance of proper dormant pest management programs, and the significance of naturally occurring biological control agents in the Southern San Joaquin Valley. A good dormant program must include high volume (350 to 400 gallons of water per acre) and 6 to 8 gallons per acre of oil. There were four elements of the Kern County studies initiated in 1998, 1) to develop information on the relationship between the abundance of male San Jose scale (SJS) flyers in the spring and the abundance of first generation crawlers, 2) to study the influence of pruning on scale abundance, and 3) to study the influence of nitrogen application on scale abundance.

Two orchards were monitored for adult male scale to try to determine the relationship of pheromone trap catches to scale crawlers. In one of the orchards, 6 tent traps baited with Pherocon® SJS pheromone lures were monitored. In two trees within the row, one on each side of the tree with the trap, a single limb, selected at head height, was selected for monitoring crawlers. A one inch wide band of double sided sticky tape was placed around the limb and sampled weekly to determine crawler density. The second orchard was monitored in the same manner using both pheromone and sticky traps at 20 sites throughout the orchard. The data has not been summarized to date, in part because of the departure of James Brazzle as UC Farm Advisor in Kern County. We intend to summarize these data as part of a larger study that is being conducted this year with Walt Bentley and Marjie Bartels.

Table 2. Locations of orchards being monitored in Kern County San Jose Scale study.

Orchard number	Name	Location
1	Rosedale	Stockdale Ranch, Bellevue Rd.
2	Shafter #1	Riverside St.
3	Shafter #2	Rosales, Palm Ave.
4	Wasco #1	Amcal, McCombs Rd.
5	Delano	Billings Rd.
6	McFarland	Peterson Rd.
7	Buttonwillow	Tracy Ave.
8	Wasco #2	Tut Bros., Schofield Ave.
9	Shafter #3	Randall, Zerker Ave.

Because of the heavy rainfall in the winter of 1998, it was not possible to apply dormant spray treatments in an orchard sufficiently infested with San Jose scale to run an experiment. However, an alternative was to determine the effects of several hullsplit treatments timed for navel orangeworm control on San Jose scale and their parasites. James Brazzle conducted such a trial in Kern County. Treatments were applied from July 15 - 17 with a standard orchard sprayer to 8.7 acre replicates. Treatments consisted of Success (spinosad), Lorsban (chlorpyriphos) + Guthion, Imidan (phosmet), and Stealth oil. All treatments together with an untreated control were replicated 3 times. Nut samples (200 nuts per sample) were collected on August 27 and hand cracked to measure damage by navel orangeworm and peach twig borer. San Jose Scale and parasite populations were monitored using pheromone traps (6 traps per treatment replicate) at monthly intervals beginning on August 14 and continuing through December 3, 1998. Spider mites were monitored at biweekly intervals from July 23 through September 3 by collecting 15 leaves per tree from 4 trees in each treatment replicate, and mite brushing and counting the samples.

Results of this study indicated significant reduction in navel orangeworm by all treatments relative to the untreated control ($F = 2.96$, $p<0.0486$), and significant reduction of peach twig borer relative to the untreated control by the Imidan and Lorsban + Guthion treatments ($F = 3.05$, $p<0.0247$) (see Table 3). Significant treatment differences were also observed in overall kernal damage (navel orangeworm, peach twig borer and ants combined) ($F = 5.59$, $p = 0.0008$). Both San Jose scale adults and the parasite *Encarsia* sp. were significantly reduced with the use of the organophosphate treatments Imidan and Lorsban + Guthion. The Success and Stealth oil treatment did not impact the San Jose scale populations, but the parasites were also unaffected. Results are given on Table 4 for San Jose scale and *Encarsia* sp. populations at the peak observed in the traps on October 8, and on November 6 for the *Aphytis* sp. While on the surface this appears to be problematic in terms of San Jose scale control, these treatments will continue to be followed in 1999 to determine if the parasites that remain in the 'softer' treatments will have an impact on the San Jose scale populations on these trees in the subsequent year.

Table 3. Kernal damage at harvest following hullsplit applications.

Treatment	Mean ± SE[1] % navel orangeworm damage	Mean ± SE[1] % peach twig borer damage
Success @ 6 oz./A	0.60 ± 0.23 a	0.80 ± 0.13 a
Lorsban 4E @ 2 qts./A + Guthion @ 2 lbs/A	0.60 ± 0.36 a	0.60 ± 0.25 a
Imidan 70-WSB @ 5 lbs./A	0.40 ± 0.07 a	0.60 ± 0.29 a
Stealth oil @ 2 gal./A	0.80 ± 0.13 a	1.10 ± 0.30 ab
Untreated Control	2.30 ± 1.38 b	2.00 ± 0.25 b

[1]Means followed by the same letter do not differ significantly ($p<0.05$) by LSD.

Table 4. Peak San Jose scale adult and parasite populations measured on San Jose scale pheromone traps following hullsplit applications.

Treatment	Mean ± SE[1,2] San Jose scales/ trap	Mean ± SE[1,3] *Encarsia* sp./ trap	Mean ± SE[1,4] *Aphytis* sp./ trap
Success @ 6 oz./A	392.0 ± 83.8 b	31.6 ± 9.4 b	4.8 ± 1.3 b
Lorsban 4E @ 2 qts./A + Guthion @ 2 lbs/A	162.0 ± 27.0 a	16.4 ± 4.0 a	1.8 ± 1.2 a
Imidan 70-WSB @ 5 lbs./A	128.6 ± 26.6 a	6.0 ± 0.5 a	1.8 ± 0.6 a
Stealth oil @ 2 gal./A	421.9 ± 37.3 b	58.0 ± 12.7 c	4.6 ± 0.6 b
Untreated Control	568.3 ± 84.6 c	59.4 ± 14.5 c	1.3 ± 0.5 a

[1]Means followed by the same letter do not differ significantly ($p<0.05$) by LSD.
[2]peak observed on October 8, 1998
[3]peak observed on October 8, 1998
[4]peak observed on November 6, 1998

James Brazzle conducted a trial in the winter of 1998 to determine the effect of various dormant spray treatments against the peach twig borer. The orchard was a fifth leaf orchard in Kern County, and each treatment replicate was 0.58 acres in size. All treatments were applied with a standard airblast orchard sprayer at 125 gallons per acre, 120 PSI and 2.5 mph. All treatments were replicated 3 times, and included Volck supreme oil at four gallons per acre. Treatments included Success (spinosad), Asana (esfenvalerate) at 0.05 lbs. ai per acre, Pounce (permethrin), Asana at 0.025 lbs. ai per acre, plus Supracide (methidathion) at 1 lb. Ai per acre, Supracide at 2 lb. Ai per acre, Lorsban (chlorpyriphos), Sevin (carbaryl), Imidan (phosmet) and an untreated control. Peach twig borer twig strikes were counted on May 14, 1998. Three trees were samples from each treatment replicate. Spider mites were sampled by collecting 15 leaves per Nonpariel tree from three trees per treatment replicate, and mite brushing and counting the leaves.

Peach twig borer populations were very low in this trial, and the cool spring weather resulted in shorter than usual shoot elongation making counting of shoot strikes unusually difficult. Because of this low population, treatment differences were difficult to detect, however significant effects were determined by analysis of variance (F = 2.51, df = 9, p = 0.014). Only the permethrin and esfenvalerate plus methidathion treatments differed significantly from the control (see Table 5).

Table 5. Number of peach twig borer twig strikes per tree

Treatment	Mean ± SE PTB PTB strikes/ tree	LSD
Success @ 0.089 lbs. a.i./A	1.56 ± 0.56	abc
Asana XL @ 0.05 lbs. a.i/A	2.44 ± 0.29	c
Pounce @ 0.2 lbs. a.I/A	1.44 ± 0.29	abc
Pounce @ 0.1 lbs. a.i./A	0.33 ± 0.19	a
Asana XL @ 0.025 lbs.ai/A + Supracide 25 WP @ 1 lb.a.i/A	0.89 ± 0.11	ab
Supracide @ 2 lbs.a.I/A	1.78 ± 0.29	bc
Lorsban @ 0.75 lbs.a.I/A	2.00 ± 0.19	bc
Sevin XLR @ 1 gal/A	2.44 ± 0.44	c
Imidan 70-WSB @ 3.2lbs.a.i/A	2.00 ± 0.19	bc
Untreated Control	2.33 ± 0.33	c

In the pyrethroid (4 treatments), organophosphate (3 treatments), carbamate (1 treatment) and spinosad (1 treatment) treatments, web-spinning spider mite populations peaked at 19, 14, 14, 11; 9, 8, 7; 9 and 6 mites per leaf, respectively. Differences between treatments were indicated by analysis of variance (F = 2.58, df = 9, p = 0.007). Treatment differences were also observed for European red mite adult (F = 4.93, df = 9, p < 0.001) and egg (F = 6.00, df = 9, p < 0.001) populations, with the pyrethroid treatments having higher populations than observed in the untreated control trees. These results confirm those of previous years, and indicate a potential for secondary mite outbreaks when pyrethroid dormant sprays are used.

Objective 3. The susceptibility of peach twig borer to the organophosphate dormant sprays has been questioned by growers in several locations, but no data on possible pest resistance has been developed. In 1997, we sampled peach twig borer populations from Butte, Colusa, Glenn, Kern (2 sites), Merced, Stanislaus and Solano/ Yolo Counties. PTB larvae were removed from the shoot strikes which were gathered from each field site, and placed into individual capped containers containing a standard bean diet. After all of the larvae were placed onto the diet, a drop of one of 5 sequential dosage rates of diazinon, esfenvalerate or spinosad mixed in acetone was applied topically to each larva. The larvae were held at 68°C in an environmental chamber for 48 hours before assessing mortality by prodding the larvae with a needle probe and observing movement. A minimum of 8 larvae (and as many as 15 depending on the number of larvae available from each of the collections) were subjected to each dosage rate.

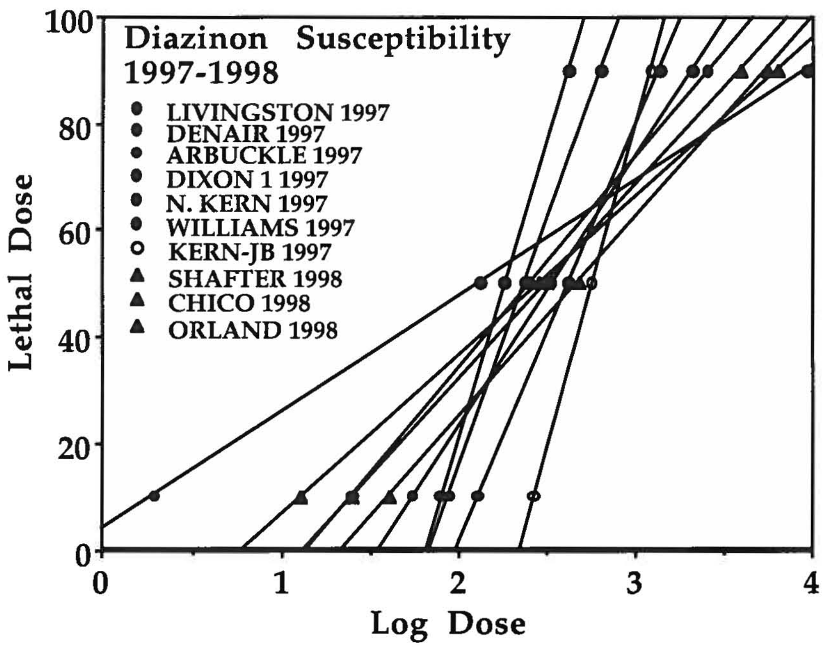
In 1998, we sampled sites in Kern, Butte and Glenn Counties. Because of low population densities at the other sites in 1998, we could not obtain sufficient numbers of larvae to perform bioassays in as many sites as in 1997. All of the peach twig borer populations sampled were susceptible to diazinon, but there was considerable diversity in range of susceptibility, with LD 50 values ranging from less than 200 ppm (Arbuckle and Dixon) to about 2 to 5 fold higher in the Kern Co. orchards and at Williams. There may be concern about elevated tolerance at the latter sites. Results to date for populations tested for diazinon are presented in Table 6 and on Figure 1.

Table 6. Bioassay results for diazinon in ppm for peach twig borer populations sampled in 1997 and 1998.

Year	Location	LD 50	LD 90	Slope
1997	LIVINGSTON	338.35	2089.8	50.59
1997	DENAIR	238.43	642.1	92.98
1997	DIXON	194.21	1518.0	44.79
1997	ARBUCKLE	184.05	420.0	111.63
1998	SHAFTER	474.29	5494.4	37.60
1998	CHICO	286.16	6272.5	29.83
1998	ORLAND	312.24	3834.0	36.73

All of the peach twig borer populations sampled were susceptible to esfenvalerate (Asana), but there was less of a range of susceptibility than occurred for diazinon for most locations. This is not unexpected since the pyrethroids have been used in almond orchards for a relatively short period of time. Virtually all of the orchards had LD 50 values of about 1 to 1.5 ppm. However, two Sacramento Valley sites had LD 50 values of 2 to 6 times than in the other sites, and LD 90 values (the dosage required to kill 90% of the exposed population) even higher than that. These sites had a history of pyrethroid use dating back 5 years. Results to date for populations tested for esfenvalerate are presented in Table 7 and on Figure 2.

Figure 1. Susceptibility of peach twig borer populations to diazinon in 1997 and 1998.



As a result of our work to date, we believe we now have identified the range of dosages that will allow assessment of LD 50 and LD 90 values of California peach twig borer populations. The range of LD 50 and LD 90 values for diazinon are 135 ppm to 566 ppm, and 420 to 6272 ppm, respectively. The range of LD 50 and LD 90 values for esfenvalerate are 0.15 to 9.01 ppm and 0.92 to 38.84 ppm, respectively. The LD 50 and LD 90 values for spinosad are 0.12 and 6.59, respectively. The dosage rates we recommend using to determine susceptibility of populations are given on Table 8. We will validate these dosages using field populations from different parts of the state in the spring of 1999. To conduct the test for diazinon and esfenvalerate, a drop of a particular dose of one material (placed into acetone as a carrier) is applied to a larva that has been removed from a twig and placed on diet with a microsyringe. To conduct the test for spinosad, a larvae must be immersed into the matierial which was diluted in water. Our results have shown that acetone can not be used as a carrier for spinosad. Following application, the larvae are held at 68°C, and each larva is observed periodically to determine survival.

Growers who have been using pyrethroids without interruption as dormant or in season sprays for several years should monitor peach twig borer twig strikes in their orchards to avoid an unexpected increase in populations.

Table 7. Bioassay results for diazinon in ppm for peach twig borer populations sampled in 1997 and 1998.

Year	Location	LD 50	LD 90	Slope
1997	LIVINGSTON	1.66	22.98	35.07
1997	DENAIR	1.49	18.69	36.38
1997	DIXON	3.02	35.50	37.35
1997	ARBUCKLE	1.53	20.33	35.61
1997	CHICO	9.01	23.48	96.11
1998	SHAFTER	0.74	7.55	39.71
1998	CHICO	3.31	38.84	37.39
1998	ORLAND	0.15	0.92	51.57

Figure 2. Susceptibility of peach twig borer populations to esfenvalerate in 1997 and 1998.

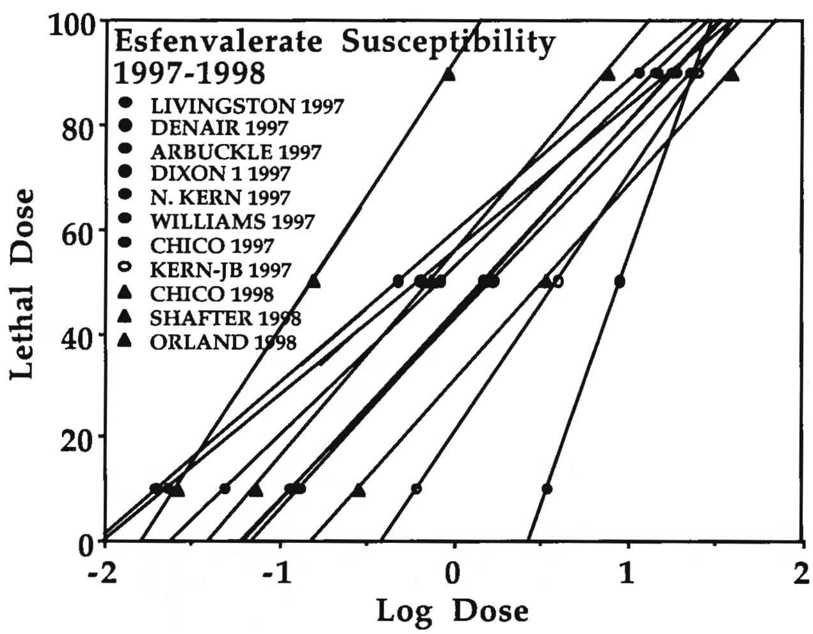


Table 8. Experimental dosage rates in ppm used to determine LD 50 and LD 90 values of California peach twig borer populations.

Diazinon	Esfenvalerate	Spinosad
10480	60.00	12.50
2620	15.00	3.13
655	3.75	0.78
164	0.94	0.20
41	0.23	0.05
	0.06	

Objective 4. In 1994, a project to evaluate the impact of reduced insecticide applications during the growing season in almonds was established in Kern County. The project involved cooperators from UC Cooperative Extension including Mario Viveros, Walt Bentley, and James Brazzle growers and representatives of several agencies. The protocol was to compare two approaches to managing insect pests in four different orchards. One of the approaches was characterized by utilizing organophosphates, carbamates, or pyrethroids in controlling navel orangeworm, peach twig borer, and ant populations. This approach, along with winter sanitation and early harvest is a conventional management technique in the Southern San Joaquin Valley. The second approach relied on less disruptive materials such as *Bacillus thuringiensis*, spinosad, dormant oils and harvest timing to regulate insect and mite populations. This study design was followed through 1997. Due to unacceptable levels of insect damage during the past two years, cooperators were unwilling to avoid the use of the more broad spectrum materials in the comparison sites in 1998. Therefore, this specific objective could not be continued as in previous years, and the focus of the program was shifted to evaluating factors which might influence the key almond pest, San Jose scale. The results of this work has been previously described under Objective 2.

Publications related to project, 1998:

Zalom, F. G., D. Walsh, M. Stimmann, C. Pickel, W. Krueger, R. Buchner, and J. Brazzle. 1998. Impact of pyrethroids on beneficial mite predators. pp. 62-67, *In* Proc. Calif. Plant and Soil Conf., Sacramento, CA.

Walsh, D. B., F. G. Zalom and M. Stimmann. 1998. Effects of pyrethroid insecticide residues on almond leaves on the biology of the western orchard predator mite *Galendromus occidentalis* (Nesbitt) (Acari: Phytoseiidae). Acta Horticulturae 470: 539-546.

Zalom, F. G., J. H. Connell and W. J. Bentley. 1998. Validation of phenology models for predicting development of the navel orangeworm *Ameylois transitella* (Walker) in California almond orchards. Acta Horticulturae 470: 525-533.

Connell, J. H. , F. G. Zalom, and W. J. Bentley. 1998. Navel orangeworm control in almond orchards with *Bacillus thuringiensis*. Acta Horticulturae 470: 547-552.

Daane, K. M., G. Y. Yokota, C. R. Anderson, W. J. Bentley, K. Olson, F. G. Zalom, J. Edstrom, and J. R. Brazzle. 1998. Inoculative releases of *Goniozus legneri* for navel orangeworm control in almonds. pp. 155-158, In M. S. Hoddle, ed. California Conference on Biological Control. Berkeley, CA June 10-11, 1998.

Zalom, F. G., M. Oliver, and D. Hinton. 1998. There're alternatives to organophosphates and oil; Check out your options. Almond Facts. 63(6): 48-52.

Zalom, F. G., and M. Oliver. 1999. Dormant treatment options. Nut Grower Magazine. 8(1): 16-24.

Zalom, F. G., M. Oliver and D. Hinton. 1999. Dormant treatment options. Pacific nut producer. 5(2): 22-24.