Annual Report to the
Almond Board of California
1/23/95

94 C16 Insect and Mite Research

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Cooperating Personnel: Walt Bentley (Objective 2) and Carolyn Pickel (Objectives 2 and 3) as co-leaders; various Farm Advisors in at least 9 counties for Objective 1, Paul Verdegaal and Bill Krueger for Objective 2, and Joe Connell, John Barry (US Forest Service), and Gary Kirfman (Entotech Inc.) for Objective 3.

Objectives:

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

2. Conduct field trials in both the San Joaquin Valley and the Sacramento Valley to further develop and validate early season exclusion as a control for spider mites. Development of thresholds, treatment timing and control materials to be applied will be of highest priority.

3. Train growers and pest control advisors in use of bloomtime *Bt* sprays and monitoring for pests in demonstration orchards, and conduct large scale field trial of aerial *Bt* applications.

Results:

Objective 1. As in prior years, this project purchased pheromone traps and lures, and other monitoring supplies for UC Farm Advisors who requested them as part of their ongoing monitoring efforts. In 1994, materials to monitor navel orangeworm, peach twig borer and San Jose scale were purchased for and distributed to Farm Advisors in 8 counties. The cost of these materials was about $3,500. The data from these plots are collected at the end of each year and are assembled at Davis where they become part of an ongoing database of trapping information that can be used for validating population dynamics of these pest species, and for various sampling studies.

Objective 2. Results of experiments with tree banding and winter soil sampling conducted in Kern County by Walt Bentley for the past three years indicated that a significant number of mated, diapausing female pacific spider mites overwinter in the soil near the base of almond trees and on the trunks of the trees. In these trials, scaffold banding of the trees successfully excluded many mites throughout the season, keeping populations below treatment thresholds. In 1993, it was found that treating the trunk and soil at early leafout with lime and sulfur gave control similar to that found with conventional acaricides without significantly affecting predatory mites. This year four major subobjectives were pursued including: 1.) Characterize the location of soil wintering mites in relation to the almond tree, 2.) Determine the depth in the soil that these mites are most abundant, 3.) Further define the time of year which movement into the tree, from the soil occurs, 4.) Investigate the use of selective materials applied to the trunks in the late winter and to the tree in early spring on the reduction of spider mites and the preservation of predator mites in almonds. and 5) validating the movement of mites in other almond growing regions of California. Additionally preliminary work was done to sample mites from various cover crops within 2 of the orchards. Populations of mites sampled from winter and spring ground cover was compared to mites collected at the same time from the soil on the tree berm.

Three orchards in Kern County were selected which had a severe Pacific mite problem in 1993. The orchards included the Wien's orchard which has been followed for the past three seasons, and two orchards owned by Wilson Farms (labeled orchard 9AN and orchard 17). The Wein's orchard is approximately 15 years old. It is a one-to-one planting of Nonpareil and Carmel, flood irrigated and planted with a barley-vetch cover crop. Ranch 9AN is drip irrigated, and a one-to-one planting of Merced, Nonpareil, and Mission. It is drip irrigated and clean cultivated. Ranch 17 is a Nonpareil, Carmel and Price orchard on a one-to-one planting and flood irrigated. Ranch 17 is mowed with resident vegetation (filaree, bermuda grass, cheese weed).

In each of the three Kern County orchards, soil samples were collected from the base of the tree near the trunk, three feet from the trunk, and six feet from the trunk. These distances were measured from both in the tree row along the berm and in the alley between tree rows. Approximately one quart of soil was collected from each of these areas around 12 individual trees within each orchard. Collections were made in early February, brought into the lab where aliquots of soil were taken and placed in seven ounce Styrofoam cups. These cups were then placed on the center of sticky San Jose Scale traps and held for two-to-three weeks. Mites emerging from the soil in the cups were trapped on the sticky trap. These were then counted and tabulated. Figures 1, 2, and 3 present results of this sampling from the Wien's, Ranch 17 and Ranch 9AN orchards. In each of these orchards, significantly more mites were collected at the base of the tree than from any other location ($P<0.01$ DMRT). At each of the orchard sites the three foot berm location showed the next largest aggregation of wintered mites. Very few mites were found at the 2 six foot locations and the three foot middle location.

January soil samples were also collected at the base of 12 trees with a specially designed augur at depths of two, four, six, and eight inches. The isolated depth samples were then placed in seven ounce cups and mite emergence recorded. The results of this sampling are shown in Figures 4, 5, and 6. Again a highly significant difference was found for the first two inches of soil ($P<0.01$ DMRT). This was followed by soil collected from two-to-four inches in depth. Very few mites were collected at six or eight inches.

Our previous work has shown that mite activity usually begins in February and can occur as late as March. This movement is consistent with observations and leaf samples showing an increase in mites moving up the tree. In 1994, soil samples were collected on a monthly basis from the base of each tree. Samples were not taken in September, October, or November. The results are presented in Figures 7, 8, and 9 for the Wien's, Ranch 17 and Ranch 9AN locations, respectively. The abundance of mites collected began to decline in March, and by April and thereafter few mites emerged. None of these orchards had a Pacific mite problem for the remainder of the year. It would be expected that the number of mites emerging in February would be equal to those in January. This difference may be due to diapausing mites which would not move from soils in January. However, once diapause is broken (typically in February) greater numbers would emerge.

The Wien's and Ranch 17 orchards were used to evaluate various early season miticide applications for their effect on both the Pacific mite and the western predatory mite. Eleven treatments, including an untreated check, were applied at the Wien's orchard (Table 1) at the equivalent of 100 GPA for the trunk treatments or 700 GPA for the foliage sprays. Leaf counts were made prior to the April sprays (10 leaves per replicate and 60 leaves per treatment). Treatments were replicated six times and applied to single trees. Evaluations were made on April 7, April 16, and June 29. The results are presented in Figure 10. There were no significant differences between treatments, probably because the Pacific mite population was quite low in this orchard and control was aided by the western predatory mite. None of the miticide applications affected survival of the western predatory mite (Figure 11).

Ten treatments (Table 1) were applied in the Ranch 17 test. Treatments were made to single trees on the same dates as in the Wien's orchard and were also replicated six times with leaf counts made as in the Wien's orchard. All foliage sprays were applied at 550 GPA. The Pacific mite population at Ranch 17 was higher than in the Wien's orchard, and significant differences were found for the Avermectin® and the combination of Vendex® and Safetycide Oil® treatments (Figure 12) on the April 12 sampling date. There were no differences on the June 15 sampling date for the Pacific mite, or for the western predatory mite on any sampling date.

To determine the applicability of the exclusion technique developed in Kern County to other almond production areas, an orchard was identified in both San Joaquin County and Glenn County for study. In each orchard, eight trees were scaffold banded with stickum and eight additional trees remained untreated as a control.

Sufficient mite populations did not occur in the San Joaquin County orchard to permit us to adequately assess the technique. Relatively low populations were also encountered in the Glenn County orchard, but interesting trends were observed (Figure 14). Spider mite populations were consistently higher on the trees that did not have bands than on those that were banded. Unfortunately, no significant difference was observed between the treatments on most dates due to tremendous variability in mite abundance between trees. As seen in the Kern County plots in prior years, little difference was observed in predator mite abundance between treatments in this orchard. This is probably due to a greater proportion of predator mites overwintering on the tree as opposed to the ground as indicated for the spider mites. Some spider mites probably remain on the tree or blow onto the tree allowing some spider mites to be present on even the banded trees. The within-tree distribution of spider mites indicates many more mites on the center foliage than on the outer foliage earlier in the year.

Objective 3. Research was conducted from 1991 through 1993 to identify guidelines for applying *Bt* during bloom to control peach twig borer. Large field trials were conducted during the past three years to evaluate the methodology both for efficacy and for nontarget effects. Adoption of bloomtime treatments with *Bt* is estimated to be approximately 20% in the San Joaquin Valley, but has been very low in the Sacramento Valley. Carolyn Pickel received a grant from the USDA-ES to train growers and PCA's in the application of *Bt* during bloom and related monitoring techniques, and worked closely with the Sacramento Valley almond Farm Advisors to do this. The program allowed participating PCA's or growers to receive $10.00 per acre for collecting data prescribed as part of the program including spur samples for San Jose scale, pheromone trap catches and peach twig borer strike counts. Seventeen orchards were involved in this demonstration. Data gathered in addition to the pest monitoring included harvest damage samples from the orchards. Table 2 indicates that damage in all of these demonstration orchards was low, with only 0.09% meat damage due to peach twig borer on average in these orchards. Navel orangeworm, which is not affected by the dormant or bloomtime *Bt* sprays, comprised the majority of meat damage, but still averaged only 0.36%. This data confirms on a large number of orchards in the Sacramento Valley that our prior research indicating that bloomtime sprays could be used effectively for controlling peach twig borer is widely applicable and presents a viable alternative to dormant sprays for control of peach twig borer.

A trial was conducted in 1992 in conjunction with John Barry, an aerial applications specialist with the U. S. Forest Service, to evaluate methodology for applying dormant and bloomtime applications by air. Preliminary evaluation has shown that conventional aerial application technology does not result in good deposition on almond trees at bloom. The 1992 trial gave good data on deposition within the tree canopy using methods recommended by the Forest Service's model for application, but we did not obtain good efficacy data because of a low population of peach twig borer in the orchard.

A large, replicated trial was conducted in Butte County to assess the aerial application of Bacillus thuringiensis at bloom to control the peach twig borer as this approach makes the technique more applicable to wet conditions and larger orchards. Treatments consisted of a conventional dormant season application of methidathion; popcorn and petalfall applications of the *Bt* product Biobit HPWP applied through conventional nozzles at five gallons per acre and 15 gallons per acre, popcorn and petalfall applications of the *Bt* product Foray 48B applied at 0.5 gallons per acre through Micronair rotary atomizers, and an untreated control. The five treatments were arranged in four randomized complete blocks. The minimum plot size was 500 trees. Spray deposits were monitored with Kromekote cards placed in the tree canopy and above the ground and below the drip line from five sample trees in the center of each plot. Peach twig borers were monitored by banding scaffolds on each of the trees with cardboard following overwintering larval emergence until the start of the first spring flight.

The aerial applications of *Bt* during bloom using conventional nozzles and either 5 gallons per acre or 15 gallons per acre dilution provided significant control of the overwintering generation peach twig borer larvae emerging from their hibernaculae relative to the untreated control as measured both by trunk bands (Table 3) and shoot strikes (Table 5). The ULV application did not provide the anticipated level of control. Deposition in the micronair application was much lower than that of the other two *Bt* applications, and this was a likely cause for the disappointing results. We believe that the micronairs were not calibrated properly for the aircraft used, and that the meteorological conditions at the time of the micronair application were not proper. The dormant organophosphate application provided the best level of control of all treatments.

Spray deposition monitored with Kromekote cards always indicated more deposition in the tree canopy than near the ground below the drip line, indicating the spray was being deposited in the canopy where it would have the greatest effect. Deposition was greatest at the higher rates. All 1,840 cards (two per can, four cans per tree, five trees per plot, 12 plots treated twice and 4 plots treated once) have been counted and droplet sizes recorded. This data is yet to be analyzed by the U. S. Forest Service to determine total deposition. We hope that in the end the data can be regressed against efficacy (Tables 3 and 5) to determine the deposition necessary for optimum efficacy.

Table 1. List of early season miticide applications applied to test effect on the Pacific mite and the western predator mite. Eleven treatments including the untreated check were applied at the Wien's Orchard at the equivalent of 100 GPA for trunk treatments and 700 GPA for foliage sprays. Ten treatments were applied at Ranch 17 at 550 GPA. Treatments were made to single trees and replicated 6 times.

Material	Rate/Acre	Date	Location
Weins Ranch-			
Vendex®	2 pts.	4/1/94	foliage
Vendex® +	2 pts.		
Safetycide Oil®	14 gal.	4/1/94	foliage
Apollo®	4 oz.	4/1/94	foliage
Apollo® +	4 oz. +		
Safetycide Oil®	7 gal.	4/1/94	foliage
Avermectin®	8 oz.	4/1/94	foliage
Spray Tech Oil	3 gal.	4/1/94	foliage
Safetycide Oil®	14 gal.	4/1/94	foliage
Stirrup M®	6 oz.	2/9/94	trunk
Best Lime-Sulfur	6 gal.	2/9/94	trunk
Volck Supreme Oil®	3 gal.	2/9/94	trunk
Untreated	----	----	----
Ranch 17-			
Vendex®	2 pts.	4/1/94	foliage
Vendex® +	2 pts. +		
Safetycide Oil®	11 gal.	4/1/94	foliage
Apollo®	4 oz.	4/1/94	foliage
Avermectin®	8 oz.	4/1/94	foliage
Spray Tech Oil	3 gal.	4/1/94	foliage
Safetycide Oil®	14 gal.	4/1/94	foliage
Stirrup M®	6 oz.	2/9/94	trunk
Best Lime-Sulfur	6 gal.	2/9/94	trunk
Volck Supreme Oil®	3 gal.	2/9/94	trunk
Untreated	----	----	----

Figure 1. Pacific mite abundance in and between tree rows, Wien's Orchard, 2/6/94.

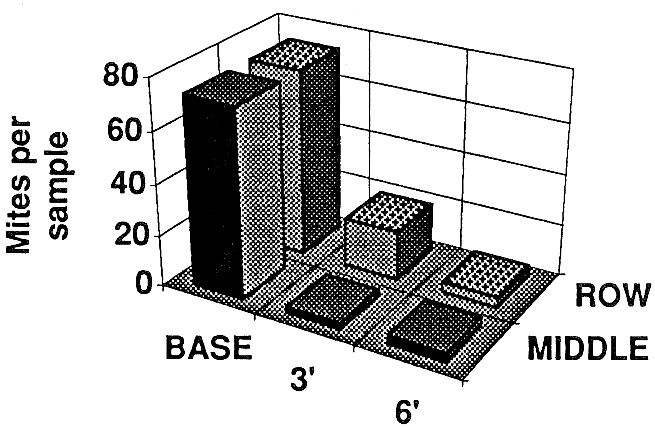


Figure 2. Pacific mite abundance in soils collected at different distances from the tree, along the berm and into the middle, Ranch 17, 2/6/94

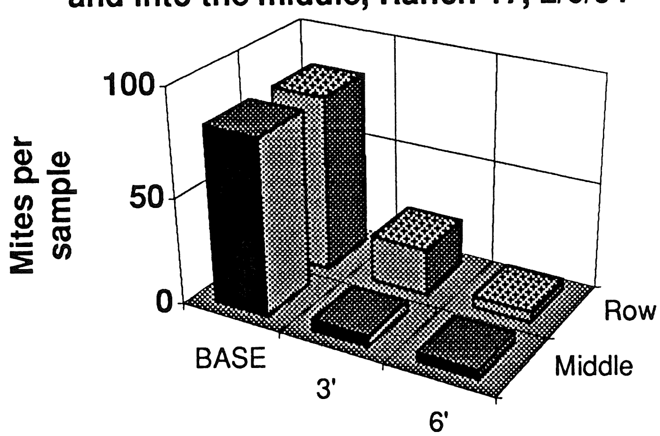


Figure 3. Pacific mite abundance in and between tree rows, Ranch 9AN, 2/6/94.

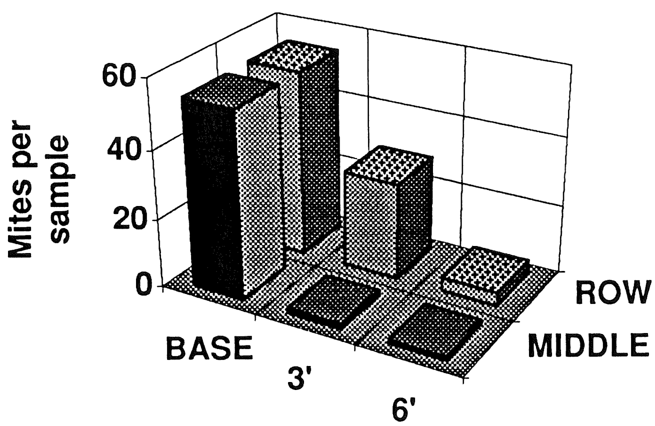


Figure 4. Pacific mite abundance from different soil depths at the base of trees, Wien's Orchard, 1/6/94.

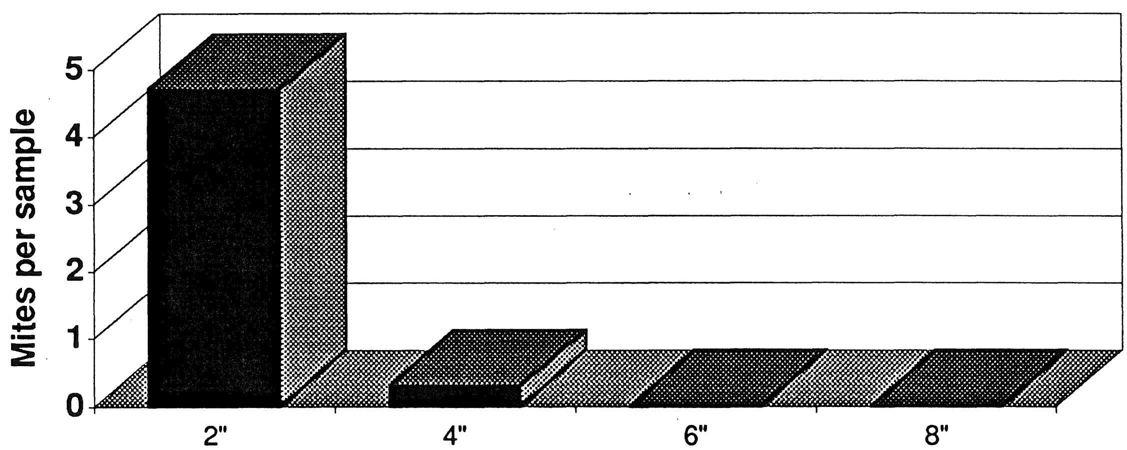


Figure 5. Pacific mite abundance from different soil depths at the base of trees, Ranch 17, 1/19/94.

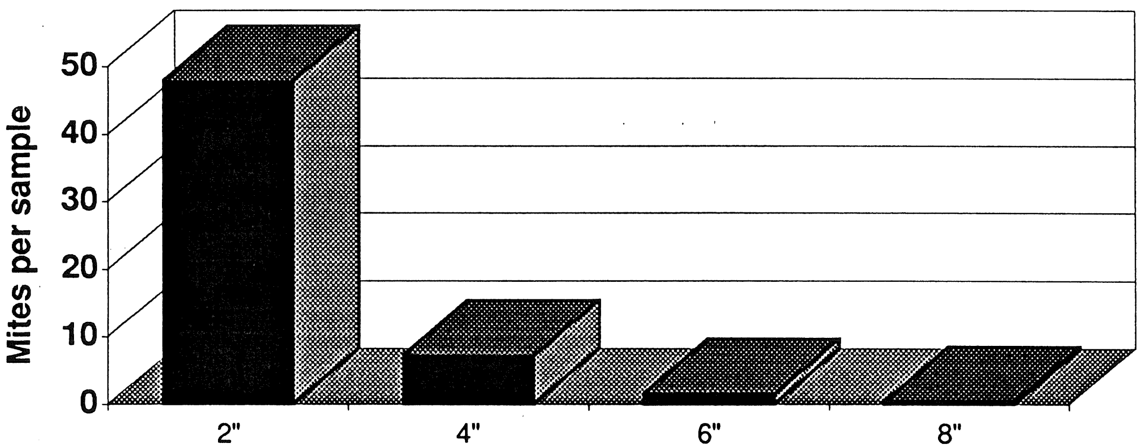


Figure 6. Pacific mite abundance from different soil depths at tree base, Ranch 9AN, 1/20/94.

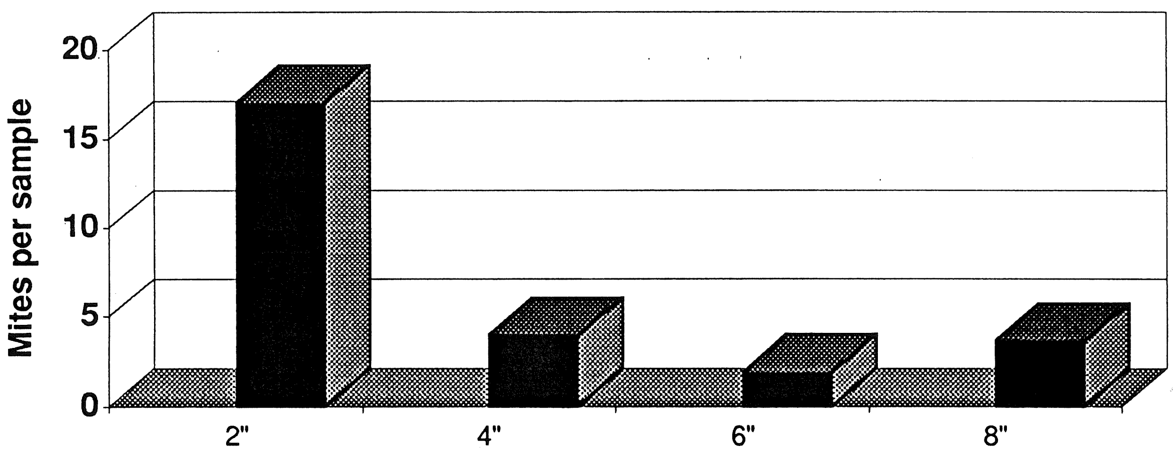


Figure 7. Pacific mite abundance from soils collected within the Weins Orchard, 1994.

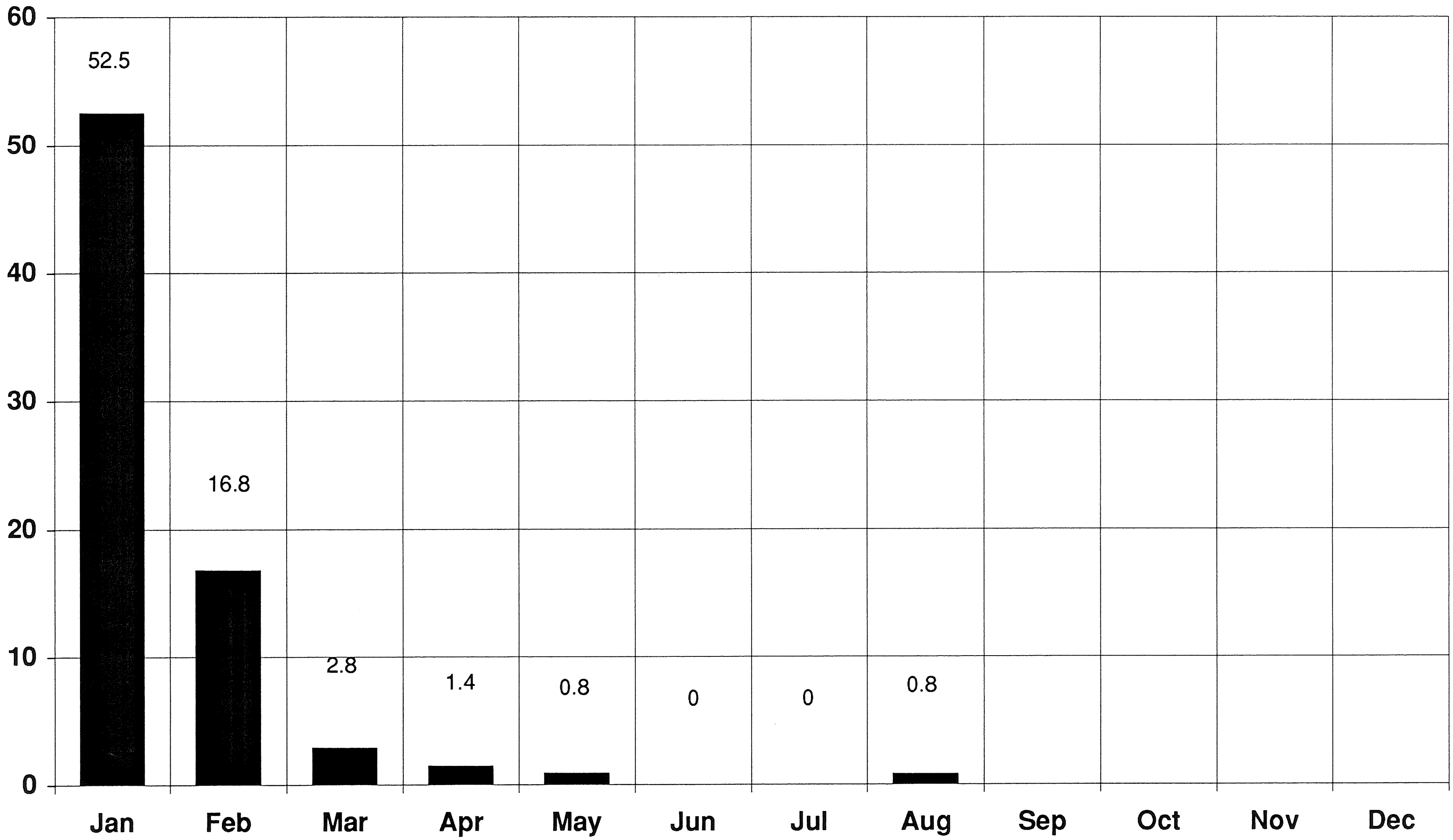


Figure 8. Pacific mite abundance from soils collected within Ranch 17, 1994.

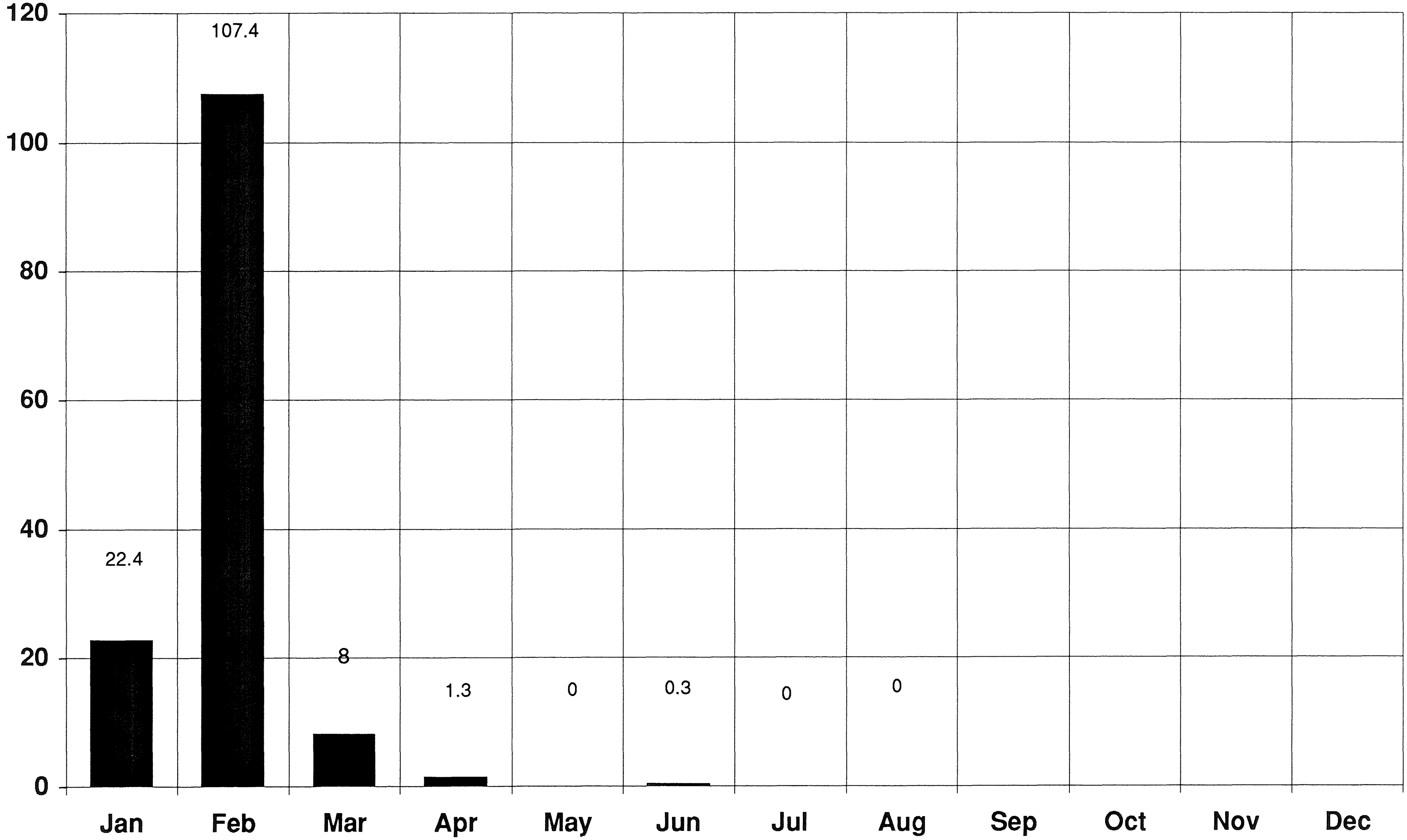


Figure 9. Pacific mite abundance from soil samples collected within Ranch 9AN,

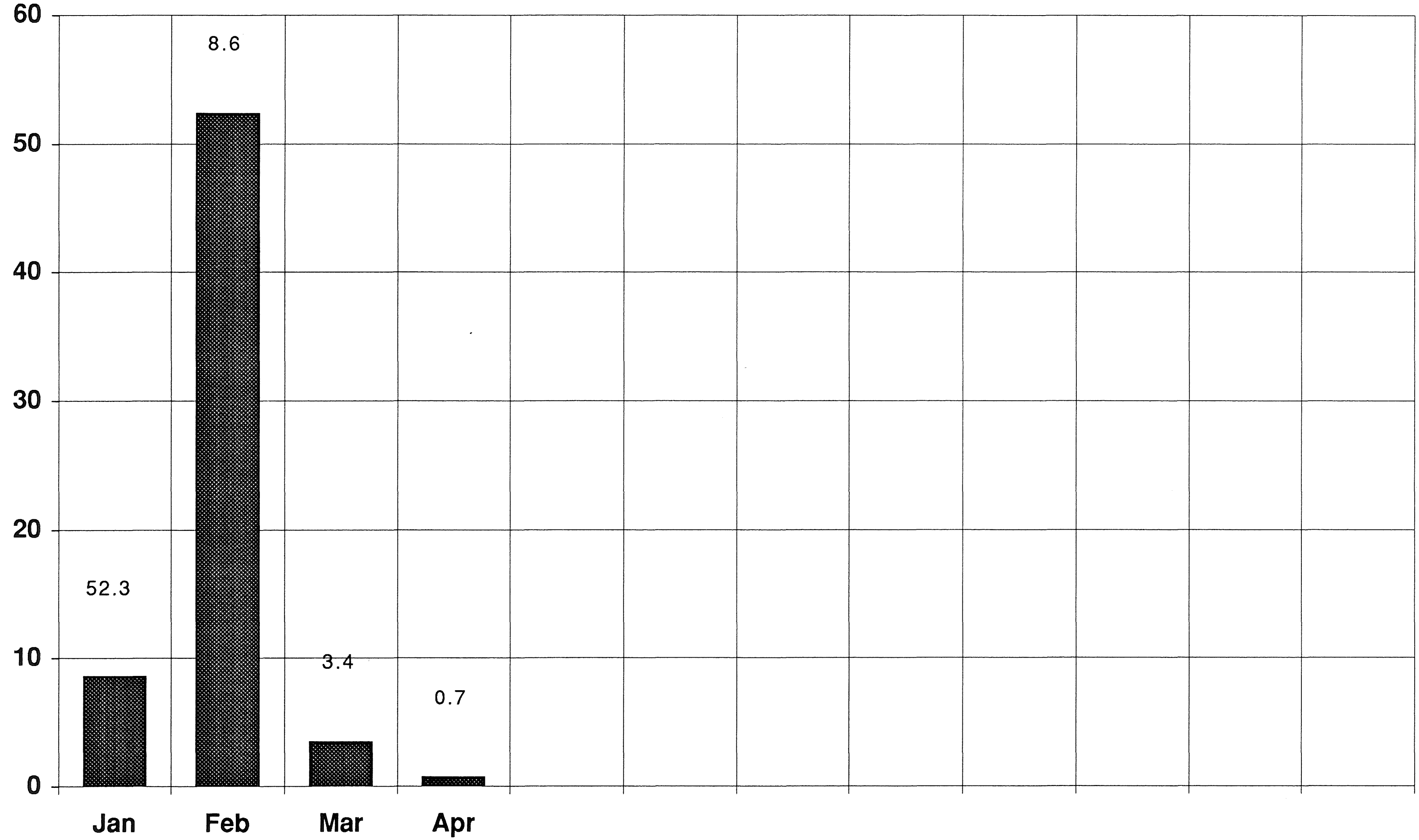


Figure 10. Effect of miticide treatments on abundance of Pacific mite, Wien's Orchard, 1994.

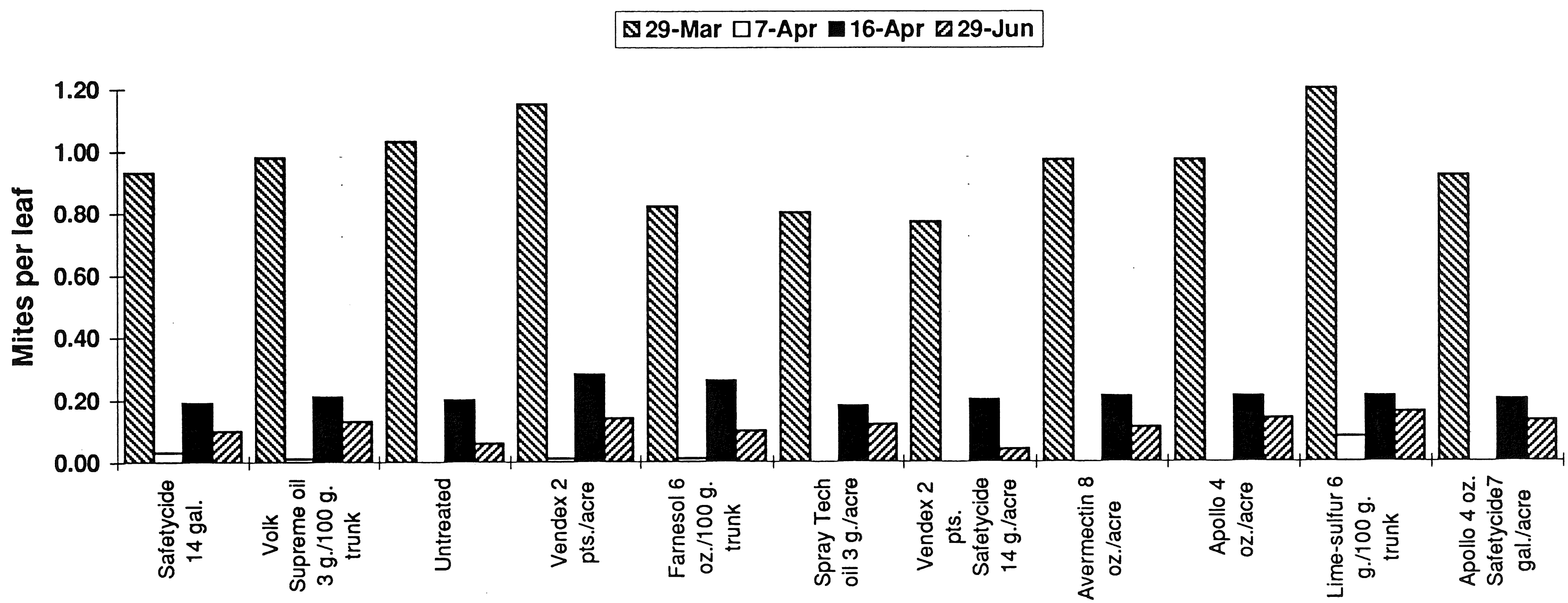


Figure 11. Effect of miticide treatments on the western predator mite, Wein's Orchard, 1994.

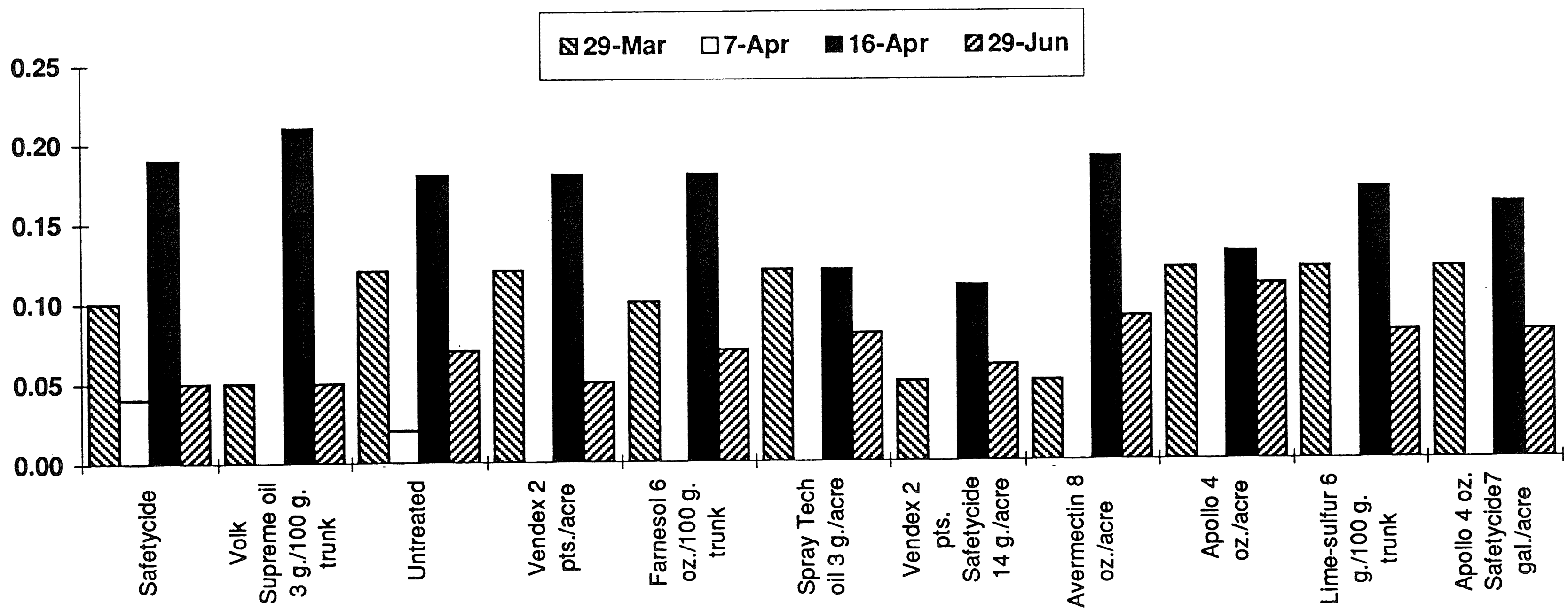


Figure 12. Effect of miticide treatments on abundance of Pacific mite, almonds, Ranch 17, 1994.

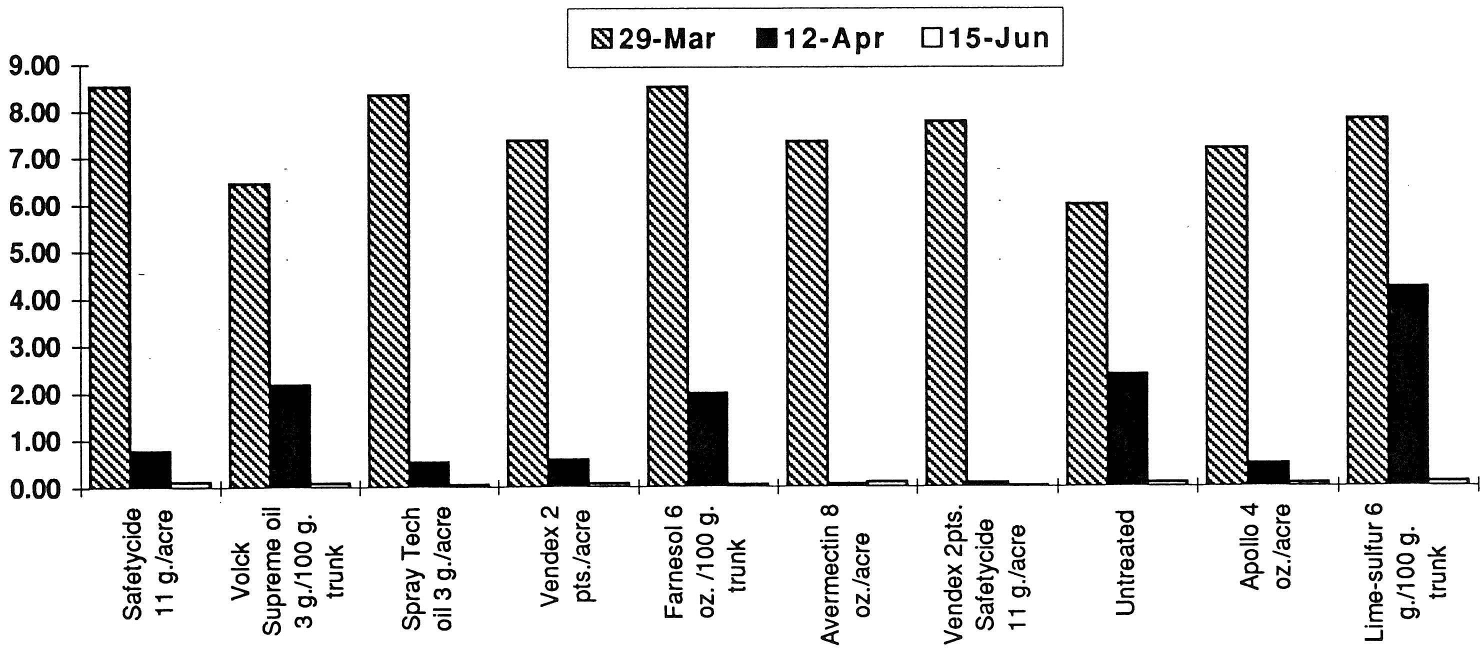


Figure 13. Effect of miticide treatments on abundance of western predator mite, Ranch 17, 1994.

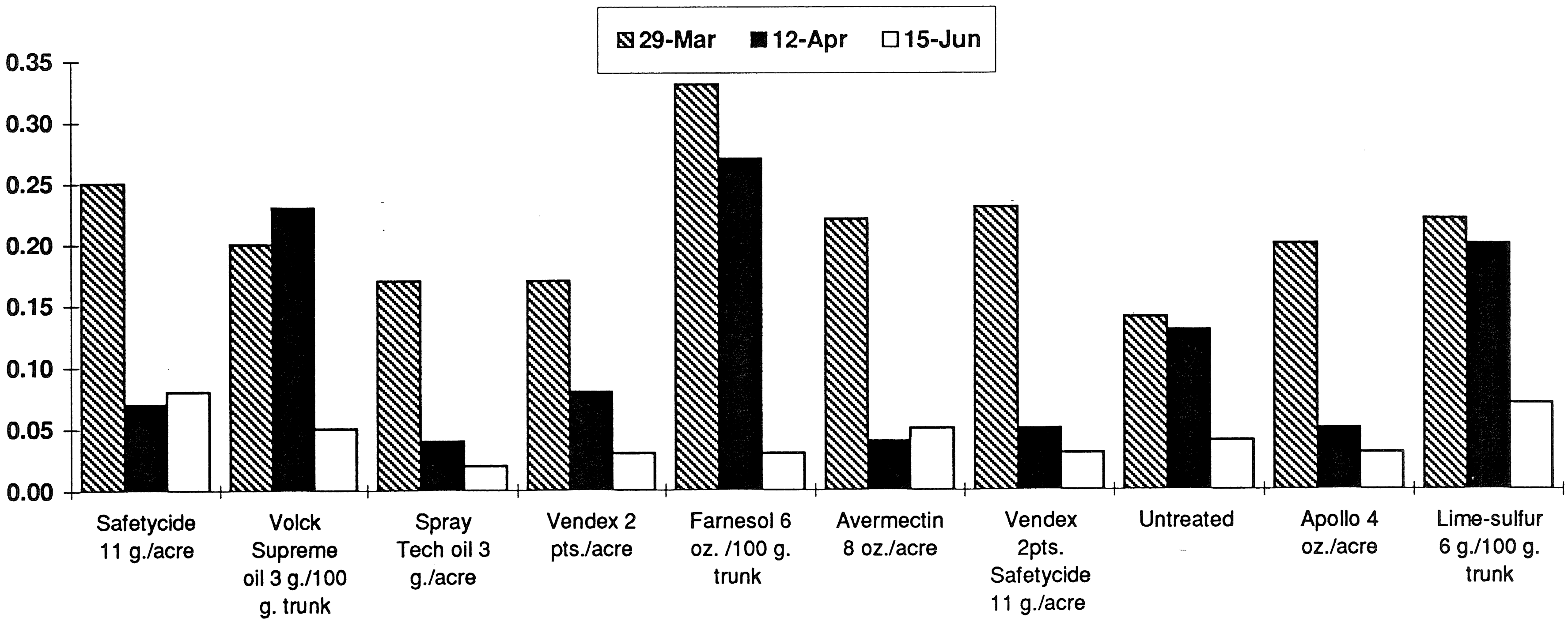
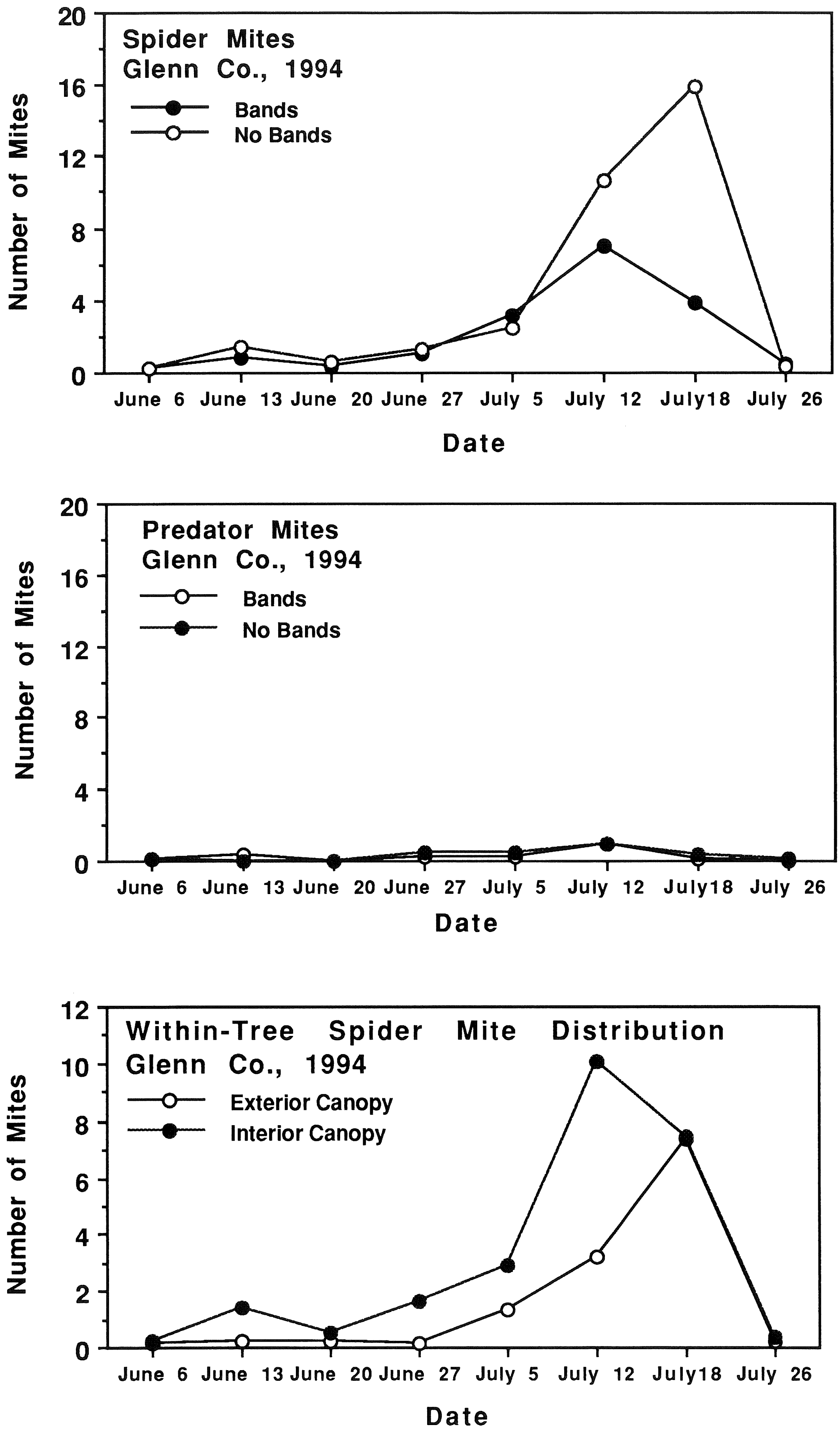


Figure 14



Spider Mites
Glenn Co., 1994
Bands
No Bands
Number of Mites
Date
June 6
June 13
June 20
June 27
July 5
July 12
July18
July 26
0
4
8
12
16
20
Predator Mites
Glenn Co., 1994
Bands
No Bands
Number of Mites
Date
Within-Tree Spider Mite Distribution
Glenn Co., 1994
Exterior Canopy
Interior Canopy
Number of Mites
Date
0
2
4
6
8
10
12

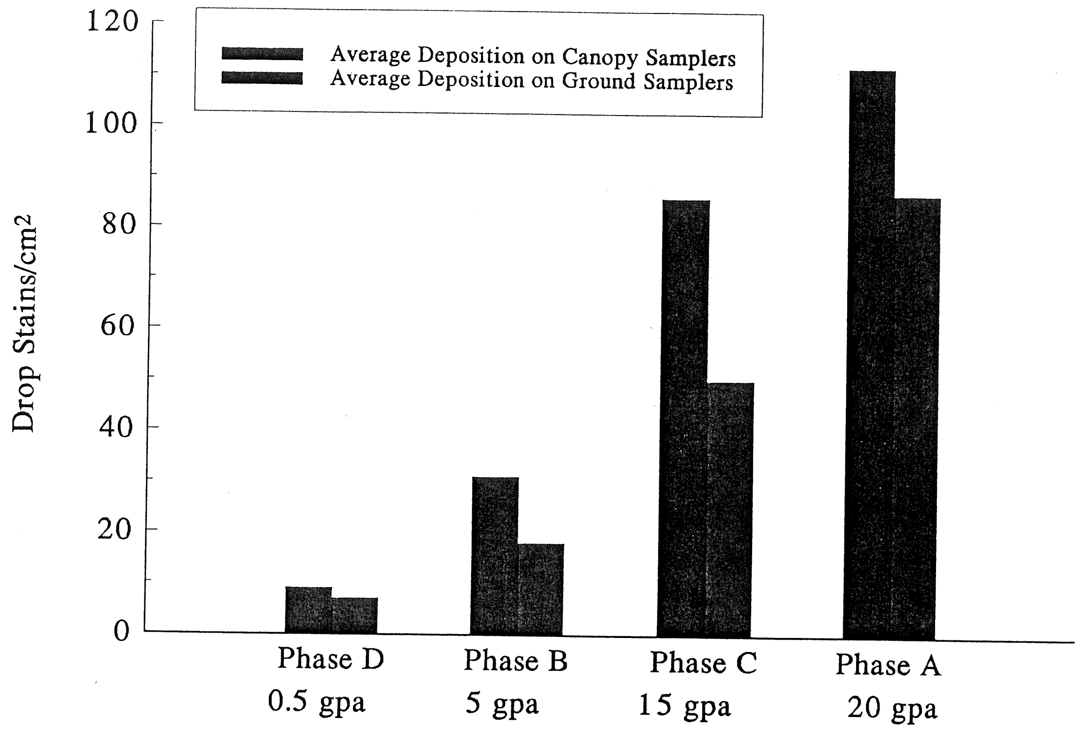


Figure -15, Mean deposition in canopy and on ground samplers for each of the three replicated treatments at popcorn stage. Phase A treatments were done at dormant stage. Hennigan Orchard, Chico, CA, 1994.

Deposit2

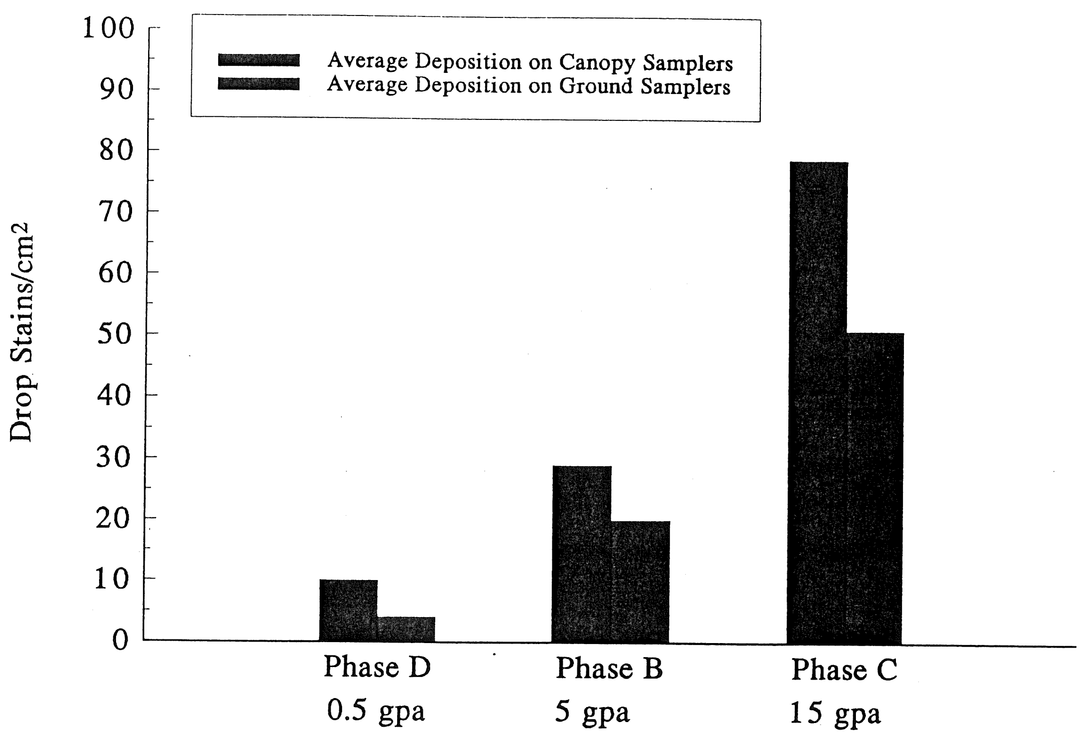


Figure -16, Mean deposition in canopy and on ground samplers for each of the three replicated treatments at petal fall stage, Hennigan Orchard, Chico, CA, 1994.

Petall

Table 2. Percentage of infested almonds at harvest in Sacramento Valley orchards treated with bloomtime *Bt* sprays for PTB. (n=17)

Insect	mean ± (SE)
PTB (in hulls)	0.11 ± (0.08)
PTB (in meats)	0.09 ± (0.07)
NOW (in hulls)	0.01 ± (0.01)
NOW (in meats)	0.36 ± (0.21)
OFM (in meats)	0.01 ± (0.01)
Ants (in meats)	0.27 ± (0.14)

Total meat damage range 0-4.6%, avg.=0.80%
Worm infestation range 0-3.6%, avg.=0.59%

Table 3. Mean number of PTB pupae per tree band. Chico, CA, 1994.

Treatment	PTB per tree band Mean ± (SE)[1/]	
Bt 5 gallons	0.35 (0.08)	a
Conventional	0.45 (0.10)	ab
Bt 15 gallons	0.52 (0.11)	ab
Bt micronaire	0.88 (0.17)	c
Untreated	1.20 (0.18)	c

[1/]Anova on column means: $F = 7.04$, df = 4, $p = 0.0001$. Values followed by same letter not significantly different by Fisher's Protected LSD.

Table 4. Mean number of spiders per tree band. Chico, CA 1994.

Treatment	Spiders per tree band Mean ± (SE)[1/]	
Bt 5 gallons	0.31 (0.08)	a
Untreated	0.45 (0.11)	ab
Conventional	0.49 (0.09)	abc
Bt micro	0.62 (0.11)	bcd
Bt 15 gallons	0.77 (0.14)	d

[1/]Anova on column means: $F = 3.65$, df = 4, $p = 0.006$. Values followed by same letter not significantly different by Fisher's Protected LSD.

Table 5. Corrected mean number of PTB strikes per tree [1/]. Chico, CA, 1994.

Treatment	Twig strikes per tree Mean ± (SE)[2/]	
Conventional	0.70 (0.40)	a
Bt 15 gallons	1.99 (0.54)	ab
Bt 5 gallons	2.14 (0.63)	ab
Bt micro	3.67 (1.17)	bc
Untreated	4.57 (0.86)	c

[1/]Means were corrected for difference in number of shoot strikes observed in untreated plot of each block.
[2/]Anova on column means: $F = 4.594$, df = 4, $p = .0140$. Values followed by same letter not significantly different by Fisher's Protected LSD.

Table 6. Meteorological data collected in open area upwind of orchard (#1) and in center of orchard (#2) at popcorn stage (February 22, 1994) application. Chico, CA, 1994.

Treatments, met station #, & data times	Spray times		Temp. (^{o}C)		Wind speed (m/sec)		Wind direction (^{o} magn. N)		Relat. humid.
	begin	end	7.0m	0.5m	7.0m	0.5m	7.0m	0.5m	(RH @ 0.5m)
All treatments	1300	1410							
Station #1									
1338-1348			13	14	4.04	3.64	303	305	44
1358-1408			13	14	4.33	3.74	302	304	44
Station #2									
1215-1225			13	13	1.88	1.47	306	309	50
1359-1409			14	14	2.64	1.88	328	324	43

Table 7. Meteorological data collected in open area upwind of orchard (#1) and in center of orchard (#2) at petalfall stage (March 8, 1994) applications. Chico, CA, 1994.

Treatments, met station #, & data times	Spray times begin	Spray times end	Temp. (^oC) 7.0m	Temp. (^oC) 0.5m	Wind speed (m/sec) 7.0m	Wind speed (m/sec) 0.5m	Wind direction (^{o} magn. N) 7.0m	Wind direction (^{o} magn. N) 0.5m	Relat. humid. (RH @ 0.5m)
Conv. 5 gpa	1115	1152							
Station #1									
1108-1118			18	19	1.46	1.45	301	306	63
1148-1158			20	19	1.48	1.55	326	335	61
Station #2									
1108-1118			19	19	1.14	0.67	260	252	59
1148-1158			20	19	0.85	0.64	306	281	54
Conv. 15 gpa	1215	1250							
Station #1									
1208-1218			20	20	1.71	1.69	289	291	59
1248-1258			21	21	0.99	1.08	273	279	52
Station #2									
1208-1218			21	20	1.13	0.82	329	304	53
1248-1258			21	21	1.26	1.04	227	233	52
Micron. 0.5gpa	1430	1500							
Station #1									
1428-1438			23	22	1.11	1.23	331	334	42
1458-1508			23	23	1.36	1.36	279	283	44
Station #2									
1428-1438			24	23	1.03	0.56	228	231	42
1458-1508			24	23	0.84	0.54	350	337	39