Pacific Spider Mite Control in the Lower San Joaquin Valley

Project No.: **07-ENTO6-Haviland**

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Interpretive Summary:

Pacific spider mite is one of the most important insect pests of almonds in the lower San Joaquin Valley. In this region, one or more miticide treatments are used annually on the majority of almond acreage. Even with miticides, however, mite-induced defoliation of entire almond orchards can become a region-wide phenomenon, as occurred during 2005.

One of the most interesting developments in spider mite management in almonds has been the recent registration of several new miticides, including a newly reformulated Apollo (clofentezine), Desperado (pyridaben + sulfur), Envidor (spirodiclofen), Fujimite (fenpyroximate), Kanemite (acequinocyl), Onager (hexythiazox), and Zeal (etoxazole). The purpose of this project was to evaluate these new miticides under a range of conditions and timings, such as at a typical May application timing, at hull split, and close to harvest, to help develop recommendations that will benefit almond pest managers in the lower San Joaquin Valley.

We have identified Zeal, Onager, Envidor and Apollo as all having good, long residual activity against Pacific spider mite when used at the May timing. Each product provided similar suppression of mites when compared with the standard Agri-Mek through hull split. Results were more variable after hull split and into harvest. Data for Zeal was statistically equivalent to Agri-Mek on all evaluation dates.

Data at hull split identified Fujimite as the best alternative to Omite, followed by Envidor.

When averaging 2006 and 2007 trial data, Zeal and Acramite also had excellent knock-down of mites at hull split but did have as long of a residual as Fujimite, Omite or Envidor. Kanemite and Acramite provided the best knock-down of mites from products with a PHI of 7 or less days.

Objectives:

1) Evaluate the effects of miticide applications on Pacific spider mite control

    a) During the spring (April/May timing)
    b) During the summer (Hull split timing)
    c) Within two weeks of harvest

Materials, Methods and Results:

a) Spring Application Trial

Season-long miticide programs in the lower San Joaquin Valley typically involve a spring miticide application in May –often referred to as the Agri-mek timing- followed by a second miticide application at hull split. In nearly all situations, mite populations during the spring timing are very low to undetectable. However, history has shown that a spring application of Agri-mek, even when utilized as a 'preventative' spray, can have long residual effects. The purpose of this trial was to determine if any of four new miticides, all growth regulators, could provide similar benefits.

This trial was conducted near Shafter, Kern Co. CA, to evaluate the effects of miticides on mite density in mature almond trees. Approximately 80 acres of trees were divided into 32, 2.5 acre plots that each contained 7 rows by approximately 30 trees (planted to a 21 by 24 ft spacing). Thirty of the plots were each assigned to one of five miticide treatments in a RCBD with 6 blocks. One additional plot was left untreated as an unreplicated control plot to be used in making general statements about mite pressure in the field. The final plot was not used in the trial.

Plots were sprayed at night on May 17, 2007 using commercial air-blast sprayers at 200 gpa. All treatments were combined with either 1% 415 Oil or a surfactant. Mite densities were evaluated in each plot prior to treatment on May 11and then Jun 6(20DAT), Jun 21 (35DAT), Jul 3 (47DAT), Jul 16 (60DAT), Jul 30 (74DAT), Aug 13 (88DAT), Aug 20 (95DAT), Aug 27 (102DAT), and Aug 30 (105DAT). On each evaluation date, two leaves were randomly collected from each of 15 trees in the center two rows of each plot in the variety 'Butte'. Leaves were transported to a laboratory where the total number of Pacific spider mite motiles (larvae, nymphs, and adults) and eggs were counted. Values for the average number of spider mite motiles per leaf and average spider mite eggs per leaf for each plot were analyzed by ANOVA using transformed data (squareroot (x + 0.05)) with means separated by LSD ($P = 0.05$).

Mite densities at the time of application ranged from 0.01 to 0.04 mites per leaf (Table 1 and Figure 1). This low density is typical for when 'preventative' miticide applications are made to almonds in the spring. After treatments there were no significant differences in mite densities for more than 10 weeks (74 DAT). During this period of time mite densities in all treated plots remained close to zero while mite densities in the unreplicated control plot indicated that mites were present in the field and began to build by 60 DAT (4.2 mites per leaf) and 74 DAT (15.6 mites per leaf). The control plot was oversprayed shortly thereafter.

Mites began showing up in treated plots by 88 and 95 DAT, with significant increases in mite density in the Apollo plots compared to all other treatments. Mite densities reached their peak in the trial during the 102 DAT evaluations, though no significant differences could be determined due to the very spotty distribution of mites in the field. On the last evaluation date 105 DAT, which was approximately 5 days to harvest, plots treated with Zeal had the lowest mite densities that were 82% lower than, but statistically equivalent to that of the next best treatment, Agri-Mek. Mite densities in plots treated with Zeal were significantly lower than those of any other plot treated with a mite growth regulator.

Table 2 shows the effects of miticide treatments on the density of spider mite eggs. These data closely reflect the data on motile spider mites.

<u>Conclusions</u>

Based on comparisons to the unreplicated control plot, all miticide treatments provided excellent, long-term suppression of Pacific spider mite. Comparisons among treatments showed that Zeal provided the best overall control of mites, which never exceeded an average of 0.2 mites per leaf for the duration of the trial. Agri-Mek provided similar control. Envidor, Onager and Apollo all also provided excellent control, though mite densities in these plots by the end of the trial were significantly higher than those treated with Zeal.

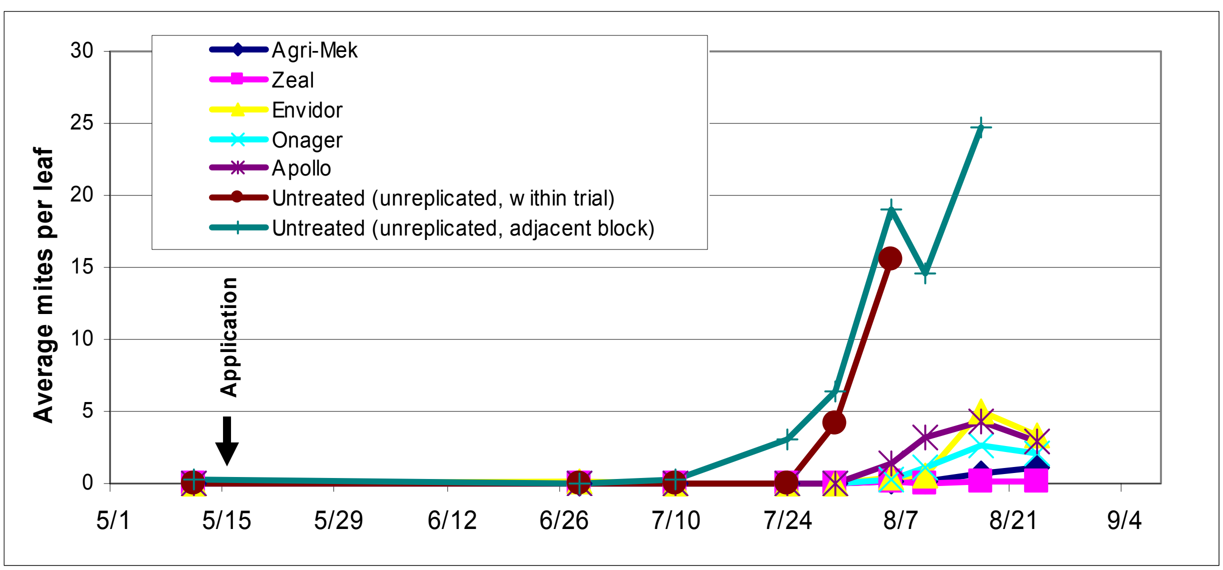


Figure 1. Effects of miticide treatments on spider mite density.

Table 1. Effects of miticide treatments on the density of motile spider mites on almond leaves through 105 DAT.

	Rate product/ac or v/v	Average spider mites per leaf							
		Pre	20 DAT	60 DAT	74 DAT	88 DAT	95 DAT	102 DAT	105 DAT
Agri-mek + 415 Oil	10 fl oz + 1%	0.04a	0.0a	0.0a	0.0a	0.1a	0.1a	0.7a	1.1ab
Apollo + Sylgard 309	8 fl oz + 2 fl oz/100gal	0.04a	0.0a	0.0a	0.1a	1.4b	3.3b	4.3a	2.9b
Onager + R-11	20 fl oz + 0.0625%	0.03a	0.0a	0.0a	0.0a	0.2a	1.1a	2.7a	2.1b
Zeal + 415 Oil	3 fl oz + 415 Oil	0.02a	0.0a	0.0a	0.0a	0.1a	0.1a	0.2a	0.2a
Envidor + R-11	18 fl oz + 0.0625%	0.01a	0.2a	0.0a	0.0a	0.4a	0.5a	5.0a	3.4b
Unreplicated untreated check[1]		0.00	0.0	4.2	15.6	-	-	-	-
F		0.48	1.0	-	2.18	5.80	5.44	1.76	3.87
P		0.7507	0.4307	-	0.1087	0.0029	0.0039	0.1774	0.0174

[1] Average mites per leaf from a single 2.5 ac unreplicated control plot. This plot was used solely for the purposes of documenting general mite pressure in the field and was not used in statistical evaluations. This plot was oversprayed shortly after the 74 DAT evaluation on 13 Aug.
Means in a column followed by the same letter are not significantly different (*P* > 0.5, Fisher's protected LSD) after square root (x + 0.5) transformation of the data. Untransformed means are shown.

Table 2. Effects of miticide treatments on the density of spider mites eggs on almond leaves, 2007.

Treatment	Rate product/acre or v/v	Average spider mites eggs per leaf			
		88 DAT	95 DAT	102 DAT	105 DAT
Agri-mek + 415 Oil	10 fl oz + 1%	0.17a	0.12a	0.37a	0.39ab
Apollo + Sylgard 309	8 fl oz + 2 fl oz/100gal	1.75b	2.38b	5.15a	2.43c
Onager + R-11	20 fl oz + 0.0625%	0.25a	0.86a	2.35a	1.98bc
Zeal + 415 Oil	3 fl oz + 415 Oil	0.15a	0.06a	0.08a	0.67a
Envidor + R-11	18 fl oz + 0.0625%	0.48a	0.26a	7.78a	3.01c
F		5.37	4.93	2.21	4.03
P		0.0042	0.0063	0.1047	0.0148

Means in a column followed by the same letter are not significantly different (*P* > 0.5, Fisher's protected LSD) after square root (x + 0.5) transformation of the data. Untransformed means are shown.

b) Hull Split Application Trial

Hull split is a critical timing for controlling spider mites in almonds throughout California. This treatment timing has historically been filled by the use of propargite (Omite) and other contact miticides such as Vendex, Acramite, Nexter and Oil. The purpose of this trial was to evaluate several newer miticides for their potential to control Pacific spider mite at hull split, and as potential alternatives to the use of propargite. We also compared two approaches to spider mite management: preventative Agri-Mek treatments in May compared to treatments of alternate miticides at an official treatment threshold later in the year.

The trial was conducted near Shafter, Kern Co. CA, in a mature block of almonds. Approximately 80 acres of trees were divided into 32, 2.5 acre plots that each contained 7 rows by approximately 30 trees (21 by 24 ft spacing). Twenty-seven of the plots were each assigned to one of 9 treatments in a RCBD with 3 blocks. The first treatment was an application of Agri-Mek applied on 17 May, 2007. Plots of the eight additional treatments were sprayed with their respective miticides at night on 3 Aug 2007 when mite densities reached an average of 7.0 mites per leaf across all plots (excluding the three that had been previously sprayed with Agri-Mek), in the trial. All treatments were made at 200 GPA with commercial air-blast sprayers. Of the five plots that remained, one was left as an unreplicated untreated check, while the other four were sprayed out and not included in the trial.

Mite densities were evaluated in each plot prior to treatment on Aug 2 and then 3, 7, 14, 21, and 27 DAT. On each evaluation date, two leaves were randomly collected from each of 15 trees in the center two rows of each plot in the variety 'Butte'. Leaves were transported to a laboratory where the total number of Pacific spider mite motiles (larvae, nymphs, and adult), were counted. Average densities of spider mite motiles were analyzed by ANOVA using transformed data (squareroot (x + 0.05)) with means separated by LSD (P = 0.05).

Plots treated with Agri-Mek in May never had spider mite densities exceed 0.1 per leaf for the duration of the trial (Table 3). Other plots reached treatable levels by late July and were treated about 10 days later when mite densities had increased to 7.0 mites per leaf (range of averages from 3.4 to 9.8 mites per leaf). After treatment, mite densities decreased to below 2.2 mites per leaf in all treated plots through 14 DAT, despite the fact that mite densities in the unreplicated control plot began at 6.4 mites per leaf and increased to 19.0, 14.6, and 24.7 mites per leaf during the same period of 3, 7 and 14 DAT respectively. This suggests that all miticides effectively reduced spider mite densities compared to precounts despite the fact that statistical comparisons among treatments for any given evaluation date were not significant.

By 21 and 27 DAT there were larger differences in average mites per leaf among treatments, though they were also not significantly different. This was primarily due to two factors. First, there were only three replications of each treatment. Second, and even more important, was that there was a huge amount of variation inherent to the trial due to the very spotty nature of where mites showed up in the large plots. One entire block had mite densities across all treatments that averaged less than 0.5 per leaf during the whole trial while another block had per leaf averages that ranged from 0.2 to 11.7 mites per leaf (27DAT). With this amount of in-field variation we were not able to get significant differences in the data.

Conclusions

When compared anecdotally to the unreplicated control plot, all treatments provided significant knock-down of spider mites. This is also true when comparing pre- and post-treatment counts for individual treatments. However, due to the large amount of variation, we were not able to get significant differences among treatments for any given evaluation date. This is similar to results last year where all treatments provided significant reductions compared to the untreated check (which was replicated in that trial), but where there were no significant differences among treated plots for any one evaluation date.

Comparisons of a May application of Agri-Mek to other miticides at hull split showed that the best strategy for this field was the Agri-Mek. However, it is important to note that the hull-split miticide applications of miticides went on about 10 days later than they should have. Miticides should have been sprayed at about 2 mites per leaf, but were instead sprayed once mites reached an average of 7 mites per leaf. It will be important to see more trials of this type over multiple years before coming to any conclusions over which is the best overall approach to spider mite management.

Table 3. Effects of miticide treatments on the density of motile spider mites on almond leaves.

			Average spider mites per leaf					
	Form prod/ac or v/v	App. Date	Pre	3DAT	7DAT	14DAT	21DAT	27DAT
Agri-Mek + 415 Oil	10 fl oz + 1%	17 May	0.0a	0.0a	0.1a	0.0a	0.0a	0.1a
Apollo + Sylgard 309	8 fl oz + 2 oz/100gal	3 Aug	3.4b	0.8a	0.4a	0.3a	0.4a	1.1a
Onager + 415 Oil	20 fl oz + 1%	3 Aug	4.3b	2.6a	0.7a	0.1a	1.7a	2.7a
Vendex + R-11	2.5 lbs + 0.125%	3 Aug	5.6b	2.0a	2.2a	2.1a	4.5a	7.0a
Fujimite + 415 Oil	2 pt + 1%	3 Aug	6.8b	0.0a	0.3a	0.1a	0.2a	0.9a
Envidor + R-11	18 fl oz + 0.125%	3 Aug	7.6b	0.7a	0.3a	0.5a	0.5a	0.6a
Acramite + 415 Oil	1 lb + 1%	3 Aug	8.8b	0.1a	0.1a	0.2a	0.4a	0.5a
Zeal + 415 Oil	3 oz + 1%	3 Aug	9.4b	0.5a	0.2a	0.3a	1.1a	1.8a
415 Oil	2%	3 Aug	9.8b	0.4a	0.8a	1.4a	2.5a	1.4a
Unreplicated control			6.4	19.0	14.6	24.7	-	-
F			2.49	0.80	0.68	1.73	1.70	2.37
P			0.0570	0.6117	0.7057	0.1658	0.1743	0.0671

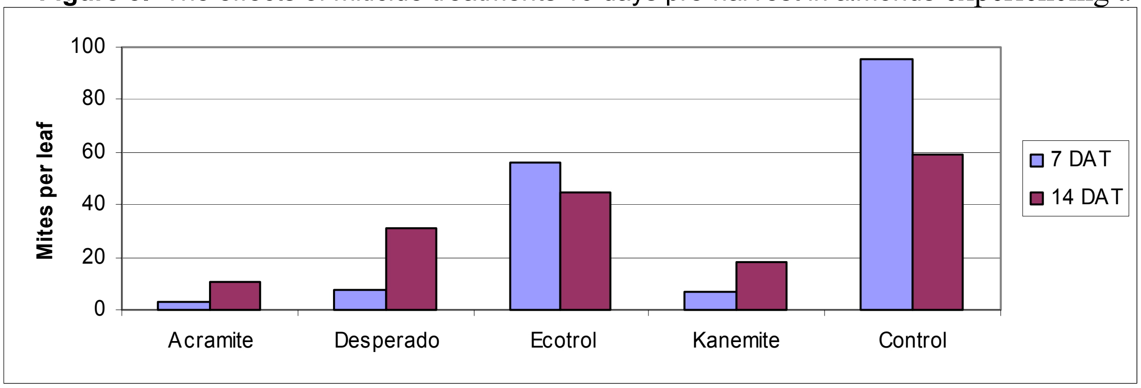
Means in a column followed by the same letter are not significantly different
($P > 0.5$, Fisher's protected LSD) after square root (x + 0.5) transformation of the data. Untransformed means are shown.

c) Trial at a 7 day PHI

Sometimes despite one's best intentions, spider mite outbreaks can occur close to harvest when pre-harvest intervals severely limit management options. This trial was conducted to evaluate four miticides (Acramite, Desperado, Ecotrol and Kanemite), with a 7 day or less PHI for their ability to knock down mite densities under an outbreak situation close to harvest.

Ten days prior to harvest each of the four miticides was sprayed onto four, 0.7 acre plots using an air-blast sprayer at 250 GPA of water. Treatments were evaluated by collectin 30 leaves per plot on each evaluation date. Mite densities at the time of application averaged 68 mites per leaf, and increased to 95.3 and 59.1 by 7 and 14 DAT. The decrease in mite densities in the control plots from 7 to 14 DAT was because all of the most heavily infested leaves had fallen to the ground. As for treatments, by 7 DAT Acramite, Desperado and Kanemite all reduced mite densities to below 10 per leaf

Figure 3. The effects of miticide treatments 10 days pre-harvest in almonds experiencing a



(**Figure 3**). By 14 DAT only Acramite and Kanemite kept mite densities under 20 per leaf.

Discussion:

We are making considerable progress in determining the best way to utilize new miticides in management programs. Of all of the new miticides, we have identified Zeal as the best alternative to, or product to use in alternate rotations with, Agrimek during a traditional spring application timing. Envidor, Onager and Apollo also worked well at that timing. At hull split we have identified Fujimite as the best alternative to Omite, followed by Envidor. When averaging 2006 and 2007 data, Zeal and Acramite also had excellent knock-down of mites at hull split but did have as long of a residual as Fujimite, Omite or Envidor. Similar results to those of our hull split trial were seen in our July nonbearing almond trial that is include in the 2006 Almond Board Reports. Kanemite and Acramite provided the best knock-down of mites from products with a PHI of 7 or less days.

The next step in our research is to utilize information from all of the trials, and future trials, to determine how to make improvements to current management programs. For example, we plan to answer questions such as whether or not preventative Agrimek treatments are still the best management option in the spring, and whether or not we can utilize new miticides as effective alternatives to Omite. We will also utilize information from existing, and future miticide trials to develop the best possible approaches to resistance management for spider mites.