2007 Woolly and Green Apple Aphid Control Trial in Apples
Utah Agricultural Experiment Station, Kaysville, UT

Diane Alston and Thor Lindstrom
Utah State University

Objectives and Background:

The efficacy of a new Bayer CropScience insecticide, Movento 150SC® (spirotetramat), for suppression of woolly apple aphid (*Eriosoma lanigerum*) and green apple aphid (*Aphis pomi*) populations in apple was evaluated. Factors compared included two rates of Movento 150SC® (8 and 12 oz/acre), three adjuvants (horticultural mineral oil; Induce®, a non-ionic surfactant; and Silwett®, a silicone oil surfactant), and one versus two applications of Movento®. Performance of Movento® was compared with a grower standard, Guthion 50WP® (azinphosmethyl) at 2 lb/acre, 1% v/v horticultural mineral oil applied twice, and an untreated control. Spirotetramat belongs to a new chemical class, tetramic acids. Spirotetramat is highly systemic; when applied to foliage it is translocated within phloem and vascular tissues to shoots and roots. It's mode of action is inhibition of lipid synthesis. It is active via ingestion and effective against sucking insects.

Methods:

The apple aphid control trial was conducted in an 18-year-old 2-acre apple orchard of mixed cultivars ('Delicious', 'Gala', 'Idared', 'Jonathan', 'Mutzu', and 'Prime Gold') at the Utah State University research farm in Kaysville, UT. Orchard spacing was 12 ft between trees and 20 ft between rows. Plot size was 2 rows wide by 5 trees long (40 ft x 60 ft; 0.06 acre per plot). Treatments were replicated four times and plots were arranged in a randomized complete block design (see plot map). All treatments were applied with an orchard air blast sprayer at 140 psi and 100 gpa. This spray pressure and rate provided adequate volume for complete coverage of trees. Tree canopy height ranged from 10-20 ft.

All aphid treatments were applied at petal fall on May 9. Treatments 2 and 6-9 received a second application 33 days later on June 11. Spray water was acidified to pH 6-7 with a buffering agent.

Other pesticides applied included the fungicides Flint (April 13), Procure (May 8), and Rally (May 24 and June 9) for suppression of powdery mildew. To reduce fruit infestation by codling moth, Isomate CTT® mating disruption pheromone dispensers were hung in the orchard immediately after codling moth biofix.

Treatments:

1. Untreated control
2. 1% v/v horticultural mineral oil applied on May 9 and June 11
3. Guthion 50 WP @ 2 lb/acre applied on May 9
4. Movento 150SC @ 8 oz/acre + 1% v/v horticultural mineral oil applied on May 9
5. Movento 150SC @ 12 oz/acre + 1% v/v horticultural mineral oil applied on May 9

6. Movento 150SC @ 8 oz/acre + 1% v/v horticultural mineral oil applied on May 9 and June 11
7. Movento 150SC @ 12 oz/acre + 1% v/v horticultural mineral oil applied on May 9 and June 11
8. Movento 150SC @ 8 oz/acre + 0.25% v/v Induce, a non-ionic adjuvant, applied on May 9 and June 11
9. Movento 150SC @ 8 oz/acre + 0.1% v/v Silwett, a silicone oil adjuvant, applied on May 9 and June 11

Aphid and Natural Enemy Sampling

Aphid densities were determined at pre-treatment on April 25 (2 weeks before treatment, WBT) and on May 22 (2 weeks after treatment, WAT), June 5 (4 WAT), June 19 (6 WAT), and July 5 (8 WAT). Sampling dates were based on number of weeks after the petal fall treatment on May 9. The percentage of shoots infested per tree (N=72 per date) and number of aphids on two shoots per tree (N=144 per date) were determined on two center trees per plot. . The percentage of shoots infested was determined by visually counting the number of shoots with each aphid type and the total number of shoots per sample tree, and calculating the percentage infested. Aphid densities were determined by collecting aphids into vials with 70% ethanol and counting the number of alate and apterous aphids of each species under a dissecting microscope (10-20X magnification) in the laboratory. The number of aphid predators (e.g., syrphid fly larvae, lacewing larvae, and minute pirate bug nymphs and adults) and parasitized aphid mummies were also determined.

Phytotoxicity Injury Assessment

Leaves and fruit were inspected for symptoms of phytotoxicity (burning, russetting, spotting, and necrosis) throughout the aphid-sampling period.

Statistical Analyses

Aphid data were statistically compared among treatments with analysis of variance within each sample date and over time using repeated measures analyses (Proc Mixed, SAS Institute). Pair-wise mean comparisons among treatments were controlled for experiment-wise Type I error and means separated using the Tukey-Kramer method. Density data were square root transformed and proportion data were arcsine-square root transformed before analysis to meet data normality assumptions.

Results and Discussion:

Woolly Apple Aphid

The mean percentage of apple tree shoots infested with woolly apple aphid (WAA) was very low before treatment and increased post-treatment in the untreated, horticultural oil, and Guthion treatments (Table 1 and Fig. 1). Shoot infestation did not exceed 2.5% in any treatment throughout the trial period; however, significant differences among treatments were detected on 4 and 8 weeks after treatment (WAT). On 4 WAT, shoot infestation in untreated plots was greater than in all others except horticultural oil alone. On 8 WAT, shoot infestation was greater in untreated plots than

in all other treatments. Infestation levels were $\leq$ 0.2% in all Movento treatments on pre- and post-treatment dates (Table 1 and Fig. 1).

Mean densities of WAA on shoots increased post-treatment in the untreated, horticultural oil, and Guthion treatments (Table 2 and Fig. 2). Numbers of WAA in all of the Movento treatments (Treatments 4-9) remained low throughout the trial. Significant differences in densities among treatments occurred on 4, 6, and 8 WAT. Numbers were significantly greater in the untreated plots than in all others. WAA densities were significantly less in most of the Movento treatments than all others, including horticultural oil and Guthion on 4 and 6 WAT (Table 2).

Green Apple Aphid

Shoot infestation by green apple aphid (GAA) was higher than for WAA. Significant differences among treatments occurred on 2, 4, and 6 WAT (Table 3). Infestation was highest in the untreated, horticultural oil, and Guthion treatments (Treatments 1-3), and significantly lower in the Movento treatments (Fig. 3). There was no consistent difference among the Movento treatments in comparison of rate (8 vs. 12 oz per acre), number of applications (one vs. two), or adjuvants (horticultural oil, Induce, or Silwett). Shoot infestation tended to increase over time in Treatments 1-3 and decline over time in the Movento treatments (Table 3 and Fig. 3).

Trends in green apple aphid densities among treatments and over time were similar to shoot infestation (Fig. 4). Again, significant differences among treatments occurred on 2, 4, and 6 WAT (Table 4). Highest densities of apterous GAA were found on 4 WAT. Densities of apterous aphids were lowest in the Movento treatments and there was no separation among the Movento treatments. Numbers of alate GAA were generally low and didn't differ among treatments except on 4 WAT.

Aphid Parasitism

Parasitism was noteworthy only in the untreated plots where woolly apple aphid densities were the most abundant (Fig. 5). Few parasitized aphid mummies were found in any other treatment. Differences in parasitism among treatments occurred on 4, 6, and 8 WAT. Parasitism was higher in the untreated plots than in all other treatments (p = 0.02, 0.01, and 0.01 for 4, 6, and 8 WAT, respectively).

Low numbers of predaceous natural enemies were observed. Lady beetle larvae, minute pirate bugs, spiders, thrips, and midge larvae were found, but numbers were too low for meaningful statistical comparisons.

Aphid Population Trends over Time

Repeated measures analyses were used to evaluate effects of treatments, sample date, and the interaction of treatment and date on aphid population trends across time. Significant treatment by date interactions for WAA (p<0.001) and apterous GAA (p<0.001) densities were found. For WAA, densities in untreated plots increased over time while densities in all treated plots remained low and similar across time (Fig. 6). For apterous GAA, densities in untreated, horticultural oil, and Guthion treatments increased to a peak on 4 WAT and then declined on 6 and 8 WAT while densities in all of the Movento treatments were low throughout the trial (Fig. 7).

Phytotoxicity Assessment

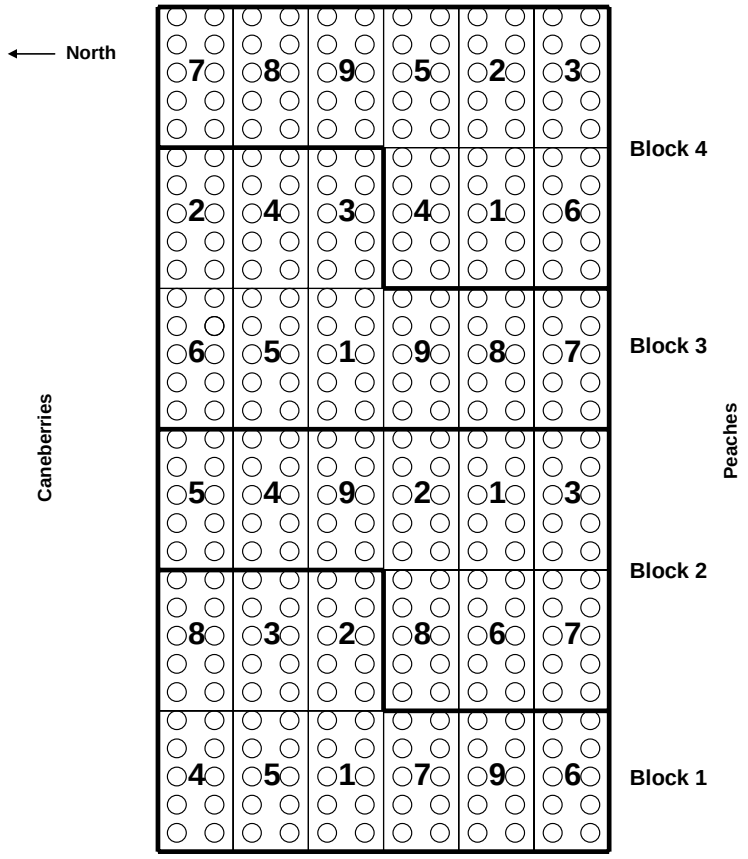
No symptoms of unusual russeting, marking, or necrosis were observed on apple leaves or fruit during the trial.

Summary and Conclusions

All of the Movento treatments were effective in suppressing woolly and green apple aphid incidence and densities for up to 8 weeks after treatment. The results were similar for all Movento treatments, so there was no effect of rate, number of applications, or adjuvant type. The first application timing at petal fall (May 9) provided excellent suppression of both aphid species. At petal fall, green and woolly apple aphid incidence and densities were very low. The Movento treatments prevented aphid populations from increasing while the non-Movento insecticide treatments, horticultural oil alone and Guthion, were not effective in suppressing woolly or green apple aphids. Aphid parasitism was low in all treatments except the untreated where abundant aphid densities supported parasitism. Predator densities were too low to distinguish differences among treatments.

Map of Kaysville IPM Apple (Mixed cultivars) Orchard
2007 Woolly and Green Apple Aphid Control Trial

Orchard size: 12 rows X 30 trees: 12' X 20' spacing; Plot size: 2 rows X 5 trees



Treatments (plot flagging color):

1. Untreated control (white)
2. 1% hort oil; 2 apps (lavender)
3. Guthion 2 lb (lime)
4. Movento 8 oz + 1% hort oil (blue)
5. Movento 12 oz + 1% hort oil (blue/white stripe)
6. Movento 8 oz + 1% hort oil; 2 apps (pink)
7. Movento 12 oz + 1% hort oil; 2 apps (pink/blk str)
8. Movento 8 oz + 0.25% Induce; 2 apps (orange)
9. Movento 8 oz + 0.1% Silwett; 2 apps (red)

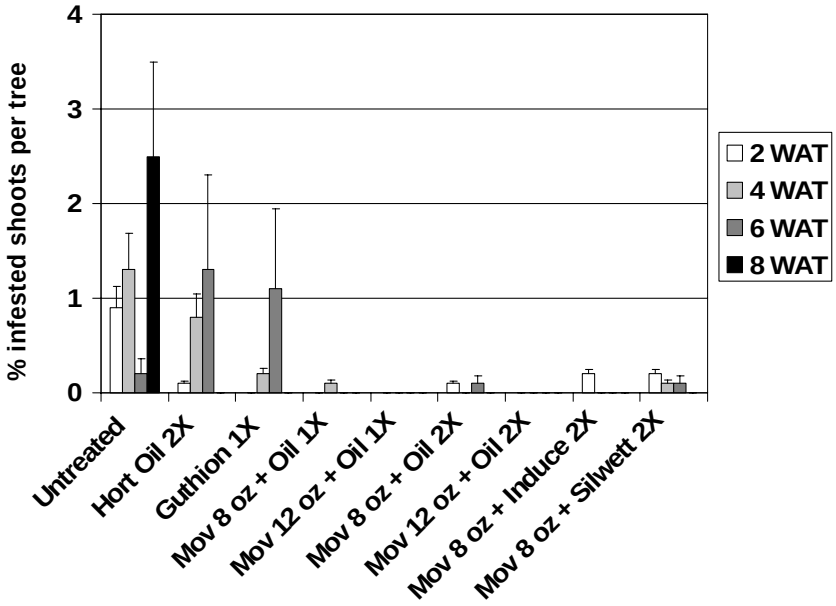


Figure 1. Influence of insecticide treatments on percentage of shoots infested with woolly apple aphid (WAA) per tree (+SE) on 2, 4, 6, and 8 weeks after treatment (WAT).

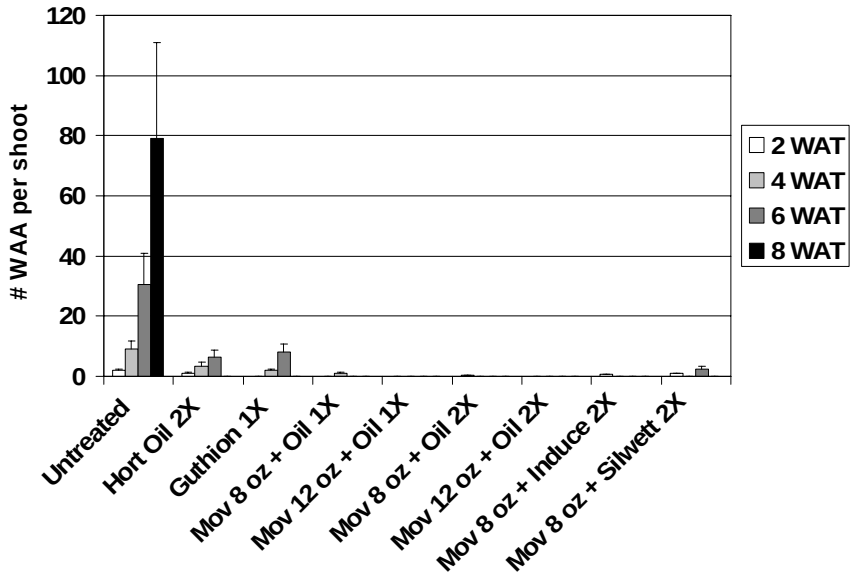


Figure 2. Influence of insecticide treatments on densities of woolly apple aphid (WAA) per shoot (+SE) on 2, 4, 6, and 8 weeks after treatment (WAT).

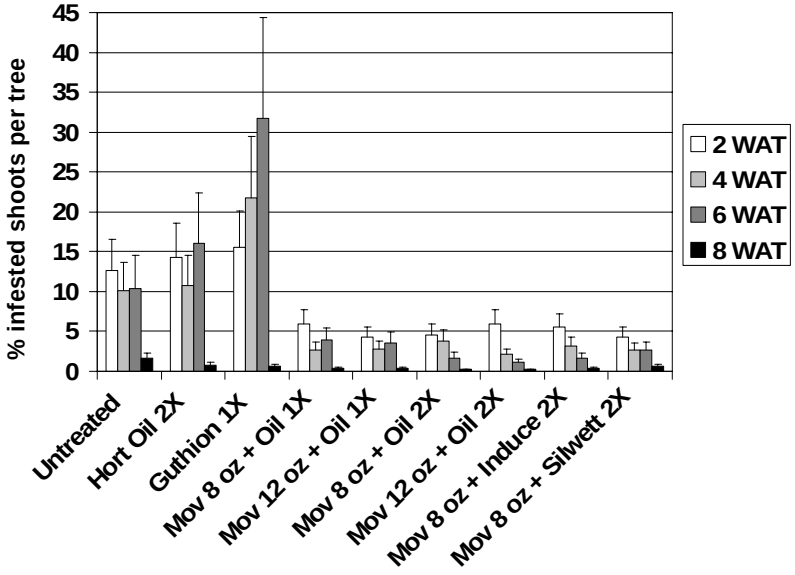


Figure 3. Influence of insecticide treatments on percentage of shoots infested with green apple aphid (GAA) per tree (+SE) on 2, 4, 6, and 8 weeks after treatment (WAT).

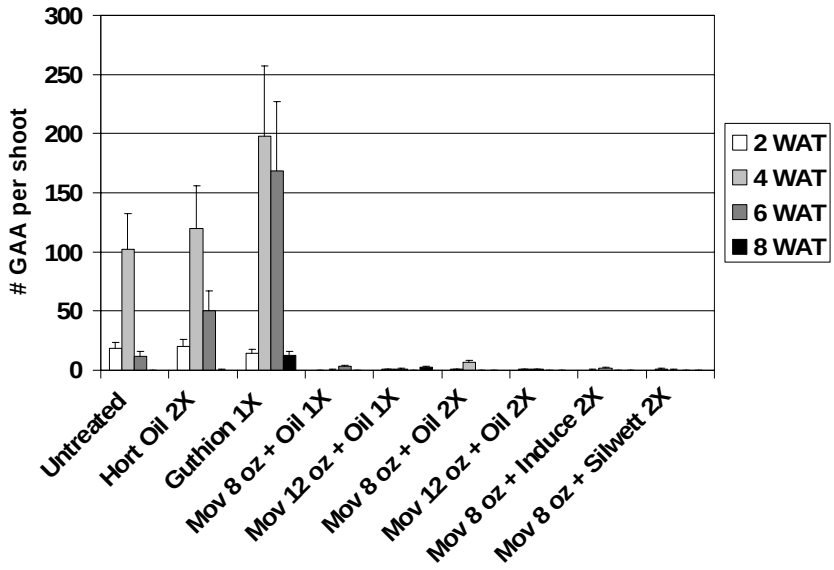


Figure 4. Influence of insecticide treatments on densities of apterous green apple aphid (GAA) per shoot (+SE) on 2, 4, 6, and 8 weeks after treatment (WAT).

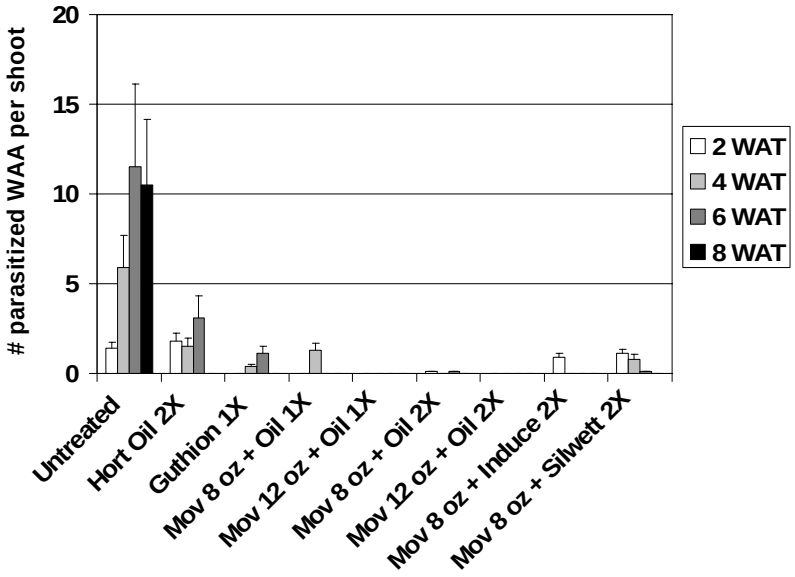


Figure 5. Number of parasitized woolly apple aphid (WAA) mummies as influenced by insecticide treatments on 2, 4, 6, and 8 weeks after treatment (WAT).

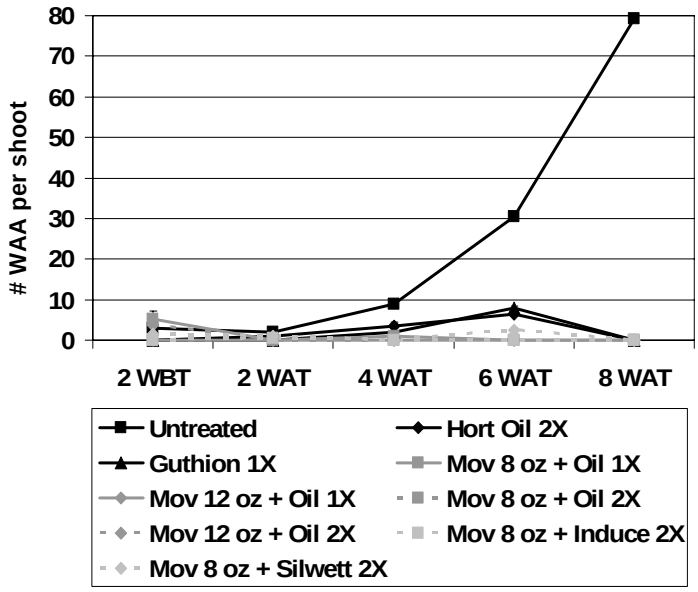


Figure 6. Influence of the interaction among insecticide treatments and sampling date on densities of woolly apple aphid (WAA) per shoot.

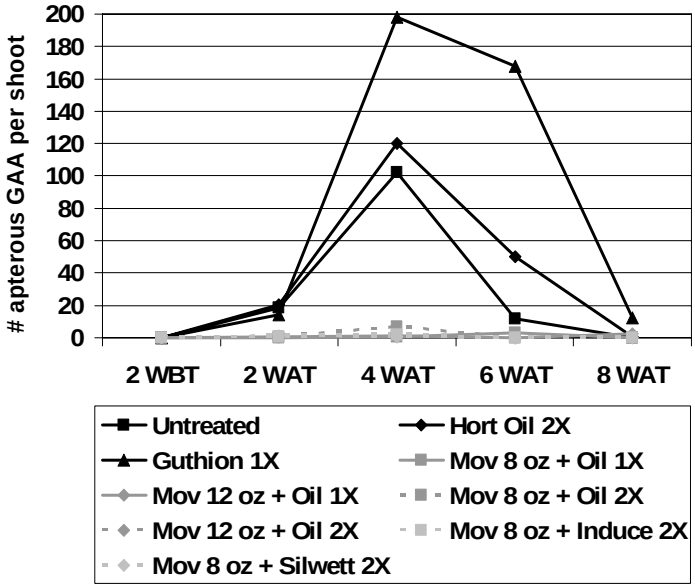


Figure 7. Influence of the interaction among insecticide treatments and sampling date on densities of apterous green apple aphid (GAA) per shoot.

Table 1. Influence of insecticide treatments on the mean percentage of apple tree shoots infested with woolly apple aphid (WAA).

Treatment and formulation	Rates (Dates of application)	Mean percentage (%) of shoots infested with WAA per tree				
		2 WBT[+] Apr 25	2 WAT* May 22	4 WAT Jun 5	6 WAT Jun 19	8 WAT Jul 5
1. Untreated		2.0	0.9	1.3 a	0.2	2.5 a
2. Horticultural oil	1% v/v (May 9 & Jun 11)	0	0.1	0.8 ab	1.3	0 b
3. Guthion 50WP	2 lb/acre (May 9)	0	0	0.2 b	1.1	0 b
4. Movento 150SC + oil	8 oz/acre + 1% v/v (May 9)	0.1	0	0.1 b	0	0 b
5. Movento 150SC + oil	12 oz/acre + 1% v/v (May 9)	0	0	0 b	0	0 b
6. Movento 150SC + oil	8 oz/acre + 1% v/v (May 9 & Jun 11)	0	0.1	0 b	0.1	0 b
7. Movento 150SC + oil	12 oz/acre + 1% v/v (May 9 & Jun 11)	0.1	0	0 b	0	0 b
8. Movento 150SC + Induce	8 oz/acre + 0.25% v/v (May 9 & Jun 11)	0	0.2	0 b	0	0 b
9. Movento 150SC + Silwett	8 oz/acre + 0.1% v/v (May 9 & Jun 11)	0.1	0.2	0.1 b	0.1	0 b
P>F		*0.69*	*0.08*	*<0.001*	*0.47*	*0.02*

[+]WBT=weeks before treatment.
*WAT=weeks after treatment.
N=72 observations per date.
Proportion data were arcsine-square root transformed before analysis to meet normality assumptions.
Treatment means were separated with Tukey-Kramer pair-wise comparisons when significantly different in analysis of variance (Proc Mixed; $p \leq 0.05$).

Table 2. Influence of insecticide treatments on mean densities of woolly apple aphids (WAA) per shoot per apple tree.

Treatment and formulation	Rates (Dates of application)	Mean number of WAA per shoot per tree				
		2 WBT[+] Apr 25	2 WAT* May 22	4 WAT Jun 5	6 WAT Jun 19	8 WAT Jul 5
1. Untreated		2.9	1.9	9.0 a	30.4 a	79.2 a
2. Horticultural oil	1% v/v (May 9 & Jun 11)	0	1.0	3.5 b	6.4 b	0 b
3. Guthion 50WP	2 lb/acre (May 9)	0	0	1.9 b	7.9 b	0 b
4. Movento 150SC + oil	8 oz/acre + 1% v/v (May 9)	5.3	0	1.0 b	0 c	0 b
5. Movento 150SC + oil	12 oz/acre + 1% v/v (May 9)	0	0	0 c	0 c	0 b
6. Movento 150SC + oil	8 oz/acre + 1% v/v (May 9 & Jun 11)	0	0.2	0 c	0 c	0 b
7. Movento 150SC + oil	12 oz/acre + 1% v/v (May 9 & Jun 11)	3.6	0	0 c	0 c	0 b
8. Movento 150SC + Induce	8 oz/acre + 0.25% v/v (May 9 & Jun 11)	0	0.6	0 c	0 c	0 b
9. Movento 150SC + Silwett	8 oz/acre + 0.1% v/v (May 9 & Jun 11)	1.6	0.9	0 c	2.5 bc	0 b
P>F		*0.48*	*0.57*	*<0.001*	*<0.001*	*<0.001*

[+]WBT=weeks before treatment.

*WAT=weeks after treatment.

N=144 observations per date.

Data were square-root transformed (x+0.1) before analysis to meet normality assumptions.

Treatment means were separated with Tukey-Kramer pair-wise comparisons when significantly different in analysis of variance (Proc Mixed; $p \leq 0.05$).

Table 3. Influence of insecticide treatments on the mean percentage of apple tree shoots infested with green apple aphid (GAA).

Treatment and formulation	Rates (Dates of application)	Mean percentage (%) of shoots infested with GAA per tree				
		2 WBT[+] Apr 25	2 WAT* May 22	4 WAT Jun 5	6 WAT Jun 19	8 WAT Jul 5
1. Untreated		0	12.7 ab	10.1 b	10.4 ab	1.6
2. Horticultural oil	1% v/v (May 9 & Jun 11)	0.1	14.3 a	10.8 ab	16.0 ab	0.8
3. Guthion 50WP	2 lb/acre (May 9)	0	15.5 a	21.8 a	31.7 a	0.6
4. Movento 150SC + oil	8 oz/acre + 1% v/v (May 9)	0	5.9 b	2.7 c	3.9 b	0.4
5. Movento 150SC + oil	12 oz/acre + 1% v/v (May 9)	0.1	4.3 c	2.8 c	3.5 b	0.4
6. Movento 150SC + oil	8 oz/acre + 1% v/v (May 9 & Jun 11)	0	4.6 b	3.8 bc	1.7 b	0.2
7. Movento 150SC + oil	12 oz/acre + 1% v/v (May 9 & Jun 11)	0.1	5.9 b	2.1 c	1.1 b	0.2
8. Movento 150SC + Induce	8 oz/acre + 0.25% v/v (May 9 & Jun 11)	0.1	5.5 b	3.2 bc	1.6 b	0.4
9. Movento 150SC + Silwett	8 oz/acre + 0.1% v/v (May 9 & Jun 11)	0	4.3 c	2.6 c	2.6 b	0.6
P>F		*0.29*	*<0.001*	*<0.001*	*<0.001*	*0.94*

[+]WBT=weeks before treatment.
*WAT=weeks after treatment.
N=72 observations per date.
Proportion data were arcsine-square root transformed before analysis to meet normality assumptions.
Treatment means were separated with Tukey-Kramer pair-wise comparisons when significantly different in analysis of variance (Proc Mixed; $p \leq 0.05$).

Table 4. Influence of insecticide treatments on mean densities of alate (AL) and apterous (AP) green apple aphids (GAA) per shoot per apple tree.

Treatment and formulation	Rates (Dates of application)	Mean number of GAA per shoot per tree				
		2 WBT[+] Apr 25 AL/AP	2 WAT* May 22 AL/AP	4 WAT Jun 5 AL/AP	6 WAT Jun 19 AL/AP	8 WAT Jul 5 AL/AP
1. Untreated		0/0	1.3/18.6 a	0.2 d/101.9 b	1.2/11.7 b	0.1/0.3
2. Horticultural oil	1% v/v (May 9 & Jun 11)	0/0.3	2.3/20.5 a	0.5 d/120.1 ab	0.6/49.9 b	0.3/0.4
3. Guthion 50WP	2 lb/acre (May 9)	0/0	2.4/14.4 a	0.9 cd/198.1 a	6.1/168.1 a	0.3/12.3
4. Movento 150SC + oil	8 oz/acre + 1% v/v (May 9)	0/0	1.9/0 b	1.3 abc/0.4 c	1.4/3.4 b	0.3/0.1
5. Movento 150SC + oil	12 oz/acre + 1% v/v (May 9)	0.1/0.1	1.9/0.9 b	1.9 a/1.1 c	1.3/0.1 b	0.4/2.6
6. Movento 150SC + oil	8 oz/acre + 1% v/v (May 9 & Jun 11)	0/0	2.7/0.6 b	1.2 abc/6.6 c	1.1/0 b	0.4/0
7. Movento 150SC + oil	12 oz/acre + 1% v/v (May 9 & Jun 11)	0/0	1.8/0.8 b	1.9 a/0.5 c	1.5/0.3 b	0.3/0.1
8. Movento 150SC + Induce	8 oz/acre + 0.25% v/v (May 9 & Jun 11)	0.1/0	1.1/0.4 b	1.4 ab/1.9 c	1.0/0.3 b	0.4/0.1
9. Movento 150SC + Silwett	8 oz/acre + 0.1% v/v (May 9 & Jun 11)	0/0	1.4/1.1 b	1.1 bc/0.4 c	1.6/0.1 b	0/0
P>F		*0.55/0.18*	*0.55/<0.001*	*<0.001/<0.001*	*0.57/<0.001*	*0.81/0.07*

[+]WBT=weeks before treatment.

*WAT=weeks after treatment.

N=144 observations per date.

Data were square-root transformed (x+0.1) before analysis to meet normality assumptions.

Treatment means were separated with Tukey-Kramer pair-wise comparisons when significantly different in analysis of variance (Proc Mixed; $p \leq 0.05$).