Ohio Apple Mite Management Trial, 2003
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Objectives: To evaluate control of European red mite by the experimental miticides Mesa and Zeal compared with Acramite, Danitol, and Pyramite, to determine the tolerance of stigmaeid and phytoseiid predatory mites to these miticides as well as to the newly registered pyrethroid, Warrior, and to evaluate the effect of these pesticides on white apple leafhopper.

Methods: A field trial was conducted at a 19-year old block of Scarlet Spur Delicious apples at OSU's Waterman Laboratory in Columbus. The experimental design was randomized complete block with four replicates of seven treatments as detailed in Table 1. Plot size was three adjacent trees; all data were taken from one central tree per plot. Treatment sprays were applied at a dilute volume of 150 gallons per acre by a handgun sprayer operated at pressure of 100 psi, with a D6 ConeTip nozzle tip. There were no pre-bloom treatments of oil or insecticide in any plot. Acramite was applied when European red mite exceeded the threshold of 2.5 mites per leaf in early summer (May until mid-June), 5 mites per leaf in mid-summer (mid-June until mid-July), or 7.5 mites per leaf in late summer (mid-July until mid-August). Zeal was applied when summer eggs were present.

Insecticide was included in all summer cover sprays, except in untreated check plots, due to recent buildup of codling moth in this block; this was a change from the typical practice of omitting insecticide in one or two cover sprays when codling moth was between generations. A higher rate of Imidan was used in this trial due to previous difficulty with codling moth control.

A standard fungicide program was used in all plots. Fungicides were applied by an AgTech 4002 airblast sprayer operated at pressure of 20 psi, with TeeJet 6510 and 6520 nozzle tips. Fungicides used were Captan at three quarter inch green (4/3/03), Captan plus Nova at pink (4/15/03) and bloom (4/23/03), and Captan plus Topsin-M at first cover (5/14/03), second cover (6/2/03), third cover (6/20/03), fourth cover (7/3/03), fifth cover (7/18/03), sixth cover (8/1/03), and seventh cover (8/20/03). For fruit thinning, NAA was applied to all plots on 5/6/03.

Mite populations on 25 randomly selected leaves per tree were evaluated at approximately 14-day intervals (range, 8 to 19 days) from late April through late August with more frequent evaluations when density was approaching the threshold. Samples of predatory mites were preserved for species verification. Plots were scouted for nymphs of white apple leafhopper three times in May, and for cumulative leafhopper damage on 30 June. The population of spotted tentiform leafminer was negligible so data was not taken for this pest. Data were subjected to analysis of variance and mean comparisons by least significant difference (LSD) tests in the ANOVA procedure of the SAS statistics program. Cumulative mite-days were calculated using the treatment means and the number of days in each interval between counts.

Results and discussion: Despite unusually heavy rains in May (Table 2), European red mite populations developed to high density in 2003. Application of Pyramite at petalfall resulted in an immediate decline in density of European red mite motiles, and mites remained below threshold for the remainder of the season (Table 3). Application of Warrior at petalfall resulted in an initial decline in mite density but mites rebounded rapidly and reached high density by late June. Application of Mesa alone or Zeal plus Danitol 10.7 oz/acre at first cover resulted in European red mite populations that remained below threshold for the remainder of the season. Zeal was to be applied when summer eggs were present; application as first cover spray on 14 May was well timed based on evaluation on 13 May which showed that not only were many eggs present, but about 90% of the European red mite motiles were larvae or protonymphs, and about 10% were old adults. Application of

Danitol 16 oz/A at first cover resulted in good mite suppression during May and June but mites exceeded threshold by early July. Application of Acramite at threshold as split applications 7 days apart resulted in decreased mite density but the population exceeded threshold again by early July. These trends in treatment effects on motile mites (Table 3) were similar to effects on European red mite eggs (Table 4). No phytotoxicity was observed.

The cumulative effect of treatments on European red mite is shown by mite-day totals (Table 3). A theoretical mite population that remained below but close to threshold throughout the season would have resulted in 485 cumulative mite-days by 20 August. Treatments that were below the theoretical 485 cumulative mite-days were Mesa, untreated check, Zeal plus Danitol, and Pyramite. Treatments that resulted in more than 485 cumulative mite-days were Danitol, Warrior, and Acramite.

Apple rust mite density was significantly lower in Pyramite and Warrior treatments than in the untreated check during May (Table 5). Rust mite was significantly lower in Mesa plots than in the untreated check during early June. Rust mite reached high density in all plots by late June.

Stigmaeid predatory mites were present in most plots before treatments were applied (Table 6). As in other recent years, stigmaeids in this block were adundant enough to keep European red mite below threshold in the untreated check. Stigmaeids were present but at low density throughout July and August in the Warrior treatment where European red mite was abundant, as well as in the Zeal plus Danitol and in the Pyramite treatments where red mite was not abundant. In contrast, stigmaeids were present at high density in Acramite and Danitol-alone treatments where red mite was abundant, as well as in the Mesa treatment where red mite was not abundant. The stigmaeid population in this block has shown fairly good tolerance to the pyrethroids Asana and Danitol in recent years, so the harsh effect of Warrior in this trial was surprising.

Phytoseiid predatory mites were not detected in any plots until early June. In July when European red mite reached maximum density, there was an increase in phytoseiids in all treatments. Phytoseiid density differed significantly among treatments only in early August when they were most abundant in Pyramite treatment and lowest in the untreated check (Table 7). The ratio of phytoseiids to European red mite motiles reached the desired level of at least 0.1, first in the Pyramite treatment on 23 June, then in the Mesa treatment on 7 July, then in Warrior, Zeal, and Danitol treatments by 21 July, and finally in Acramite and check treatments by 5 August. The ratio differed significantly among treatments only on 7 July when the ratio was higher in the Mesa treatment than in any other treatment (Table 8). In this block, the dominant species of phytoseiid has been *Neoseiulus fallacis* but because some *Typhlodromus pyri* were detected in 2002, phytoseiids found in 2003 were kept and will be identified during winter 2004.

White apple leafhopper was affected by treatments. Although density of leafhopper nymphs was lower than usual throughout May, there were significant differences in cumulative damage by the end of nymphal development in late June. Leafhopper was well controlled by Warrior, Zeal plus Danitol, and Danitol alone, and adequately controlled by Pyramite and Mesa (Table 9).

<u>Conclusions</u>: Mesa applied at first cover provided excellent control of European red mite and was tolerated well by both stigmaeid and phytoseiid predators, while Zeal plus a low rate of Danitol applied at first cover provided excellent red mite control but with a harsher effect on both stigmaeid and phytoseiid predators. Danitol at the higher rate of 16 oz/A provided red mite control for about 6 weeks and was tolerated well by stigmaeids and phytoseiids. The relative contributions of Zeal versus Danitol in the combined treatment were not determined but due to better red mite control and fewer predators in the combined treatment compared to Danitol alone at a higher rate, it is likely that Zeal was more active than Danitol. Pyramite applied once at petal-fall provided excellent red mite control and was tolerated by phytoseiids but was harsh on stigmaeids.

Acramite applied at threshold in late May provided mite control for about 5 weeks, and was tolerated extremely well by stigmaeids. Warrior was not expected to provide mite control but its harsh effects on stigmaeids were documented.

Table 1: Timing and rates of mite and insect treatments on Red Delicious apples in 2003 at OSU's Waterman Lab, Columbus, Ohio.

Timing >>	*Insecticide and/or miticide sprays*			
Treatment	*Petal-fall (29 April)*	*First cover (14 May)*	*2C (6/2) 3C (6/20) 4C (7/3) 5C (7/18) 6C (8/1) 7C (8/20)*	*Extra sprays (5/28 and 6/6) for mites after threshold exceeded*
Untreated check	-	-	-	-
Standard (Pyramite)	Imidan 70WP 4 lb/A + Pyramite 60W 4.4 oz/A	Imidan 70WP 4 lb/A	Imidan 70WP 3 lb/A	-
Warrior	Warrior 3.84 fl oz/A	Imidan 70WP 4 lb/A	Imidan 70WP 3 lb/A	-
Mesa	Imidan 70WP 4 lb/A	Imidan 70WP 4 lb/A + Mesa 0.077EC 20 fl oz/A + ultrafine oil 1 gal/A	Imidan 70WP 3 lb/A	-
Zeal + Danitol	Imidan 70WP 4 lb/A	Imidan 70WP 4 lb/A + Zeal 72WDG 1.4 oz/A + Danitol 2.4EC 10.7 fl oz/A	Imidan 70WP 3 lb/A	-
Danitol	Imidan 70WP 4 lb/A	Danitol 2.4EC 16 fl oz/A	Imidan 70WP 3 lb/A	-
Acramite	Imidan 70WP 4 lb/A	Imidan 70WP 4 lb/A	Imidan 70WP 3 lb/A	Acramite 50WS 0.5 lb/A (in 2 sprays 7-10 days apart) + Choice 3 qt/100 gal + Silwet 3 oz/100 gal

Table 2. Monthly precipitation in 2003 at OSU's Waterman Lab, Columbus, Ohio.

Month	*Total precipitation (inches)*	*Dates with rain over 1 inch*
April	2.14	-
May	11.44	5/5, 5/7, 5/10, 5/15, 5/20
June	2.62	6/3
July	4.27	7/23
August	12.86	8/4, 8/27, 8/29. 8/30
September	8.75	9/1, 9/22, 9/27

Table 3. Number of motile European red mite per leaf (mean of four replicates) on Red Delicious apples on nine sampling dates in 2003, and cumulative mite-days, at OSU's Waterman Lab, Columbus, Ohio.

Treatment	*Number of mites per leaf*									*Cum. Mite days*
	4/27	*5/13*	*5/21*	*6/9*	*6/23*	*7/7*	*7/21*	*8/5*	*8/20*	
Untreated	0.04	0.08	0.16 B	0.26	2.61	3.6 B	1.5 C	0.2 C	0.18	121
Standard (Pyramite)	1.90	0.02	0.08 B	0.12	0.36	5.2 B	3.3 BC	1.8 ABC	0.26	173
Warrior	1.06	0.31	1.86 B	2.87	34.32	101.0 A	5.6 AB	1.1 BC	0.40	2080
Mesa	0.03	0.02	0.00 B	0.00	0.08	0.8 B	0.9 C	0.2 C	0.04	29
Zeal + Danitol	0.52	0.54	0.04 B	0.00	0.28	1.9 B	2.8 BC	3.0 A	0.26	129
Danitol	0.16	0.30	0.12 B	0.02	2.11	31.4 B	4.6 ABC	1.3 ABC	0.34	565
Acramite	1.02	1.16	6.37 A	0.75	3.40	33.7 B	7.9 A	2.4 AB	0.20	792
P (trt effect)	*0.67*	*0.09*	*0.001*	*0.22*	*0.21*	*0.01*	*0.02*	*0.03*	*0.60*	-

Table 4. Number of European red mite eggs per leaf (mean of four replicates) on Red Delicious apples on nine sampling dates in 2003 at OSU's Waterman Lab, Columbus, Ohio.

Treatment	*4/27*	*5/13*	*5/21*	*6/9*	*6/23*	*7/7*	*7/21*	*8/5*	*8/20*
Untreated	0.00	0.2 B	0.28	1.9	8.4	10.2 C	4.4 C	0.9	0.7
Standard (Pyramite)	0.08	0.1 B	0.16	1.1	2.3	10.5 C	9.4 BC	11.1	1.9
Warrior	0.04	2.0 B	3.17	26.9	62.7	127.3 A	25.9 A	10.9	1.6
Mesa	0.00	0.02 B	0.02	0.02	0.2	1.3 C	2.0 C	0.4	0.3
Zeal + Danitol	0.00	2.2 B	1.26	0.8	0.9	6.6 C	10.1 BC	10.8	1.3
Danitol	0.02	3.0 B	1.42	0.3	16.9	35.2 BC	17.2 AB	6.9	1.7
Acramite	0.02	9.1 A	4.68	8.3	15.3	74.1 AB	20.5 AB	9.3	1.1
P (treatment effect)	*0.70*	*0.001*	*0.17*	*0.12*	*0.17*	*0.003*	*0.004*	*0.07*	*0.49*

Table 5. Apple rust mite density rating[1] (mean of four replicates) on Red Delicious apple leaves on nine sampling dates in 2003 at OSU's Waterman Lab, Columbus, Ohio.

Treatment	*4/27*	*5/13*	*5/21*	*6/9*	*6/23*	*7/7*	*7/21*	*8/5*	*8/20*
Untreated	1.8	2.8 A	3.0 A	3.0 A	3.0	2.2 B	1.8 C	1.2	1.0
Standard (Pyramite)	2.2	2.0 B	2.0 C	2.0 B	3.0	3.0 A	2.8 AB	1.5	1.0
Warrior	1.8	2.0 B	2.2 BC	3.0 A	3.0	2.8 A	2.2 BC	1.2	1.0
Mesa	2.0	2.8 A	2.8 AB	2.2 B	3.0	3.0 A	2.5 AB	1.2	1.0
Zeal + Danitol	2.0	3.0 A	2.5 ABC	3.0 A	3.0	3.0 A	2.5 AB	1.5	1.2
Danitol	2.0	3.0 A	3.0 A	3.0 A	3.0	3.0 A	3.0 A	1.5	1.0
Acramite	2.0	3.0 A	3.0 A	2.8 A	3.0	3.0 A	3.0 A	1.5	1.2
P (treatment effect)	*0.90*	*0.0001*	*0.002*	*0.001*	-	*0.004*	*0.01*	*0.94*	*0.46*

[1] Density rating scale: 0 = none; 1 = low (<5 per leaf); 2 = moderate (5 to 50 per leaf); 3 = high (>50 per leaf).

Table 6. Number of predatory stigmaeid mite motiles per leaf (mean of four replicates) on Red Delicious apples on nine sampling dates in 2003 at OSU's Waterman Lab, Columbus, Ohio.

Treatment	*4/27*	*5/13*	*5/21*	*6/9*	*6/23*	*7/7*	*7/21*	*8/5*	*8/20*
Untreated	0.02	0.02 B	0.08	0.02 BC	0.12	0.34 ABC	0.48 AB	0.18 C	0.22 BC
Standard (Pyramite)	0.00	0.00 B	0.00	0.00 C	0	0.06 CD	0.10 B	0.10 C	0.04 C
Warrior	0.04	0.02 B	0.00	0.04 BC	0	0.10 BCD	0.06 B	0.10 C	0.06 C
Mesa	0.05	0.02 B	0.06	0.10 AB	0.16	0.38 AB	0.78 A	0.86 A	0.54 AB
Zeal+Danitol	0.08	0.04 B	0.08	0.00 C	0.04	0.00 D	0.10 B	0.10 C	0.10 C
Danitol	0.10	0.18 A	0.10	0.02 BC	0.10	0.30 ABCD	0.52 A	0.74 AB	0.30 ABC
Acramite	0.08	0.06 B	0.14	0.14 A	0.04	0.52 A	0.60 A	0.44 BC	0.58 A
P (treatment effect)	*0.32*	*0.004*	*0.15*	*0.03*	*0.08*	*0.02*	*0.01*	*0.002*	*0.008*

Table 7. Number of predatory phytoseiid mite motiles per leaf (mean of four replicates) on Red Delicious apples on nine sampling dates in 2003 at OSU's Waterman Lab, Columbus, Ohio.

Treatment	*4/27*	*5/13*	*5/21*	*6/9*	*6/23*	*7/7*	*7/21*	*8/5*	*8/20*
Untreated	0	0	0	0	0.02	0.16	0.10	0.16 C	0.08
Standard (Pyramite)	0	0	0	0.02	0.02	0.10	0.34	1.38 A	0.18
Warrior	0	0	0	0	0.02	0.16	0.52	0.47 BC	0.10
Mesa	0	0	0	0.02	0.06	0.34	0.38	0.28 BC	0.02
Zeal + Danitol	0	0	0	0	0	0.08	0.42	0.61 BC	0.24
Danitol	0	0	0	0	0	0.16	0.36	0.46 BC	0.12
Acramite	0	0	0	0	0.02	0.08	0.58	0.72 B	0.14
P (treatment effect)	–	–	–	*0.59*	*0.56*	*0.55*	*0.15*	*0.001*	*0.17*

Table 8. Ratio of phytoseiid predatory mite motiles per leaf to European red mite motiles per leaf (mean of four replicates) on Red Delicious apples on nine sampling dates in 2003 at OSU's Waterman Lab, Columbus, Ohio.

Treatment	*4/27*	*5/13*	*5/21*	*6/9*	*6/23*	*7/7*	*7/21*	*8/5*	*8/20*
Untreated	–	–	–	–	0.04	0.03 B	0.06	0.55	1.00
Standard (Pyramite)	–	–	–	–	0.17	0.08 B	0.23	1.20	1.17
Warrior	–	–	–	–	0.001	0.002 B	0.10	0.39	0.27
Mesa	–	–	–	–	0	2.47 A	1.09	2.12	0.50
Zeal + Danitol	–	–	–	–	0	0.07 B	0.38	0.30	1.57
Danitol	–	–	–	–	0	0.04 B	0.13	1.45	0.20
Acramite	–	–	–	–	0.01	0.003 B	0.09	0.60	1.21
P (treatment effect)	–	–	–	–	*0.22*	*0.02*	*0.16*	*0.24*	*0.83*

Table 9. White apple leafhopper density and damage rating (mean of four replicates) on Red Delicious apple leaves in 2003 at OSU's Waterman Lab, Columbus, Ohio.

Treatment	*Mean number of leafhopper nymphs per leaf on three sampling dates*			*Mean damage rating[1] on 6/30*
	5/2 (3 days after petalfall)	*5/16 (2 days after 1st cover)*	*5/28 (14 days after 1st cover)*	
Warrior	0.00	0.00 B	0.00 B	0.17 C
Zeal + Danitol	0.02	0.00 B	0.00 B	0.29 C
Danitol	0.03	0.00 B	0.00 B	0.33 C
Standard (Pyramite)	0.00	0.00 B	0.00 B	0.62 B
Mesa	0.04	0.04 A	0.01 B	0.65 B
Acramite	0.04	0.01 AB	0.00 B	0.84 AB
Untreated	0.00	0.04 A	0.04 A	0.99 A
P (treatment effect)	*0.24*	*0.02*	*0.0075*	*0.0001*

[1] Damage rating scale: 0 = none; 1 = light; 2 = moderate; 3 = heavy.