Apple insect management by insecticides in Ohio, 2012

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Objective: A field trial was conducted for continued evaluation of insecticide options for control of apple pests with emphasis on control of the key pest, codling moth, and on new products such as Gladiator and Closer. Gladiator is a pre-mix of avermectin and zeta-cypermethrin, which was registered by FMC in June 2012. Closer is sulfoxaflor, which is under development by Dow and not yet registered, for control of aphids and other sucking pests.

Methods:

The trial was conducted in a 2-acre block of 10-year old apple trees at Ohio State University's Waterman Agricultural and Natural Resources Laboratory in Columbus, Franklin County, Ohio. There were six treatments, each with four replicates in a randomized complete block design. There were five adjacent Scarlet Spur Red Delicious trees per plot. There was a guard row of Golden Delicious, Gala, and Fuji between adjacent treatment rows.

Three pheromone traps were used to monitor the population of codling moth. The trap-based biofix was 4/20/2012. Treatments for control of first generation codling moth were applied on in the first cover spray on 5/10, which was 236 degree-days after biofix, and again on 5/24 (451 degree-days) and 6/7 (718 degree-days). A fourth cover spray was applied on 6/21 for lingering activity of codling moth. For control of second-generation codling moth, insecticides were applied in the fifth cover spray on 7/5, which was 260 degree-days after re-biofix on 6/25, and again on 7/19 and 8/2. An eighth cover spray was applied on 8/16 for third generation codling moth. Insecticides were applied in a dilute volume of 150 gallons of water per acre by a handgun sprayer operated at pressure of 100 psi, with a D6 ConeTip nozzle tip. Products and rates used, and the sequence of product combinations, are shown in Table 1.

Table 1. Sequence and rates of insecticide sprays in experimental plots of apples, Columbus, Ohio, 2012.

Treat-ment	Spray timing					
	Pink bud	Petal-fall	1C, 2C, & 3C	4C	5C, 6C & 7C	8C
1 FMC	Mustang Max 0.8EC: 4 fl oz/A	Gladiator (F9318) 0.33EW: 18 fl oz/A + oil 0.5%	Mustang Max 0.8EC: 4 fl oz/A	Imidan 70WP: 3 lb/A	Delegate 25WG: 5.2 oz/A	Imidan 70WP: 3 lb/A
2 FMC	Mustang Max 0.8EC: 4 fl oz/A	Gladiator (F9318) 0.33EW: 18 fl oz/A + oil 0.5%	Beleaf 50SG: 2.8 oz/A	Imidan 70WP: 3 lb/A	Delegate 25WG: 5.2 oz/A	Imidan 70WP: 3 lb/A
3 Valent	Lorsban 50W: 3 lb/A	Avaunt 30WDG: 6 oz/A	1C & 2C: Danitol 2.4EC, 21.33 fl oz/A; 3C: Belay 2.13SC, 12 fl oz/A	Imidan 70WP: 3 lb/A	Altacor 35WG: 3 oz/A	Imidan 70WP: 3 lb/A
4 Dow	Closer SC: 3 fl oz/A	Imidan 70WP: 3 lb/A	Delegate 25WG: 5.2 oz/A; in 2C: plus Closer SC 1.5 fl oz/A	Imidan 70WP: 3 lb/A	Altacor 35WG: 3 oz/A	Imidan 70WP: 3 lb/A
5 standard	Lorsban 50W: 3 lb/A	Avaunt 30WDG: 6 oz/A	Altacor 35WG: 3 oz/A	Imidan 70WP: 3 lb/A	Assail 30SG: 6 oz/A + oil 0.5%	Imidan 70WP: 3 lb/A
6 untreated	-	-	-	-	-	-

Insect injury was evaluated on 100 randomly selected fruit from the center of each plot, non-destructively on 6/25, and destructively at harvest on 9/13. White apple leafhopper was evaluated in the center tree of each plot by scouting one middle leaf in each of 25 fruit clusters on 4/16, 4/30, and 5/9, and by scouting the endmost five leaves of ten terminal shoots on 6/1 and 6/18. Green apple aphid was evaluated in the center tree of each plot by scouting its presence or absence on each of the five endmost leaves on each of ten terminal shoots on 5/23, 6/1, and 6/18; the number of predatory insects was also recorded. Woolly apple aphid infestation was evaluated on each of the center three trees per plot by scouting the presence or absence of the pest in a one-minute search per tree on 6/1, 6/18, and 8/1.

Mite populations were sampled in mid-July and early August. A sample of 50 randomly selected leaves was taken from one tree at the center of each plot; this sample size was twice the usual 25 leaves per plot due to low mite density. Leaves were brushed with a mite-brushing machine, and mites were counted in sub-samples to determine the average number of European red mite and predatory mites per leaf. The density of apple rust mite was rated as low (<5 mites per leaf), moderate (5 to 50 mites per leaf), or high (>50 mites per leaf) for each sample.

Data were subjected to analysis of variance (ANOVA) and mean comparisons by least significant difference (LSD) tests in the SAS 9.1 microcomputer statistics program. Percentage data were transformed by arcsine square root before analysis.

Results and Discussion:

Bud development was about 3 weeks earlier than normal. Codling moth pressure was high as indicated by large trap counts (Fig. 1). Lesser appleworm was also present; oriental fruit moth was absent.

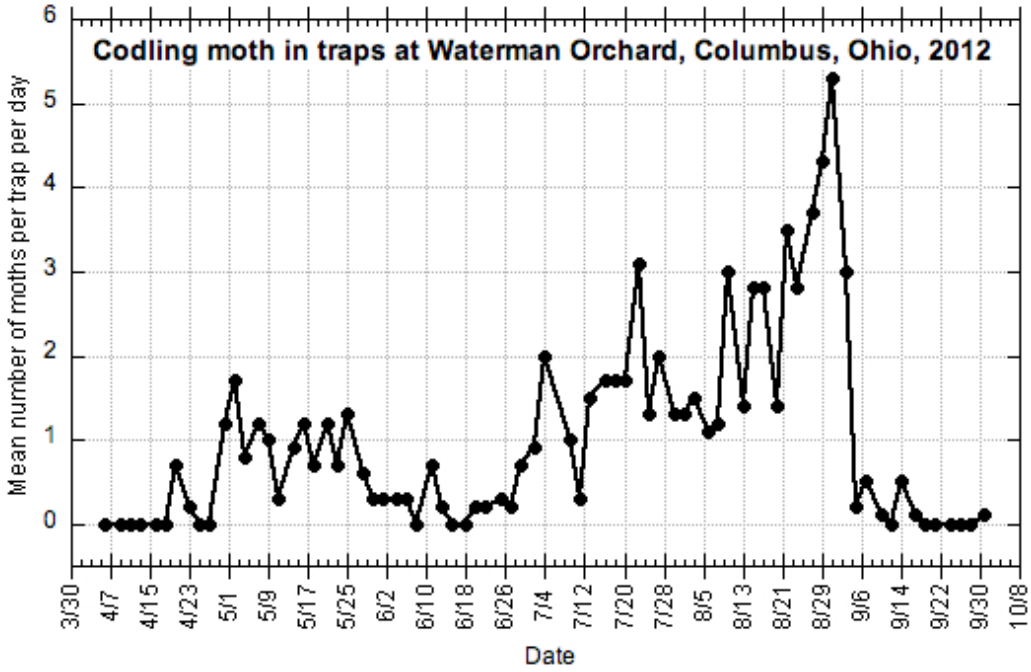

Figure 1. Seasonal trends in the adult population of codling moth as detected by pheromone trap captures in apples at Waterman Orchard, Columbus, Ohio, 2012.

The percentage of fruit that was clean of any insect damage was significantly higher in all five insecticide treatments than in untreated plots in June (P = 0.0039; Table 2) and in September (P = 0.0002; Table 3). The percentage of fruit damaged by codling moth or other internal Lepidoptera was significantly lower in all five insecticide treatments than in untreated plots in June, which reflects control of first generation (P = 0.0059; Table 2), and in September, which reflects control of the second generation

($P < 0.0001$; Table 3). Among the five insecticide programs, the fewest entries by internal Lepidoptera in June were in the Mustang Max treatment and the most entries were in the Beleaf treatment; by September, the fewest entries by internal Lepidoptera were in the treatment that used Altacor for first generation and Assail for second generation, and the most entries were in the treatment that used Mustang Max for first generation and Delegate for second generation. Other insects that caused damage to fruit were plum curculio, tarnished plant bug, woolly apple aphid, stink bugs, leafrollers, and San Jose scale, but none of these varied significantly among treatments (Tables 2 and 3). No apple maggot was detected. No phytotoxicity was observed.

Table 2. Insect injury to apple fruit after treatment by six management programs, evaluated non-destructively on 25 June 2012 at OSU's Waterman Lab, Columbus, Ohio.

Treatment	% Internal Lepidoptera			% Plum curculio	% Tarnished plant bug	% Woolly apple aphid	% Clean[a]
	Entry[a]	Sting	Total[a]				
Lorsban/Avaunt/Danitol/Belay	0.2 BC	1.8	2.1 B	4.0	2.0	0	92 A
Lorsban/Avaunt/Altacor	0.5 BC	4.0	4.4 B	3.4	0.5	0	92 A
Mustang/Gladiator/Mustang	0.0 C	2.2	2.2 B	4.8	1.0	2.0	90 A
Mustang/Gladiator/Beleaf	1.3 B	3.4	4.6 B	3.1	0.2	0.2	90 A
Closer/Imidan/Delegate	0.8 BC	4.1	4.9 B	4.7	2.5	1.7	86 A
untreated	11.7 A	5.9	17.6 A	5.7	1.5	2.5	74 B
Probability (ANOVA)	*P<0.0001*	*P=0.66*	*P=0.0059*	*P=0.81*	*P=0.08*	*P=0.11*	*P=0.0039*

[a] Within each column, means followed by same letter are not significantly different ($P>0.05$); mean separations by LSD. Values shown are actual percentages but ANOVA based on transformed values.

Table 3. Insect injury to apple fruit after treatment by six management programs, evaluated destructively at harvest on 13 September 2012 at OSU's Waterman Lab, Columbus, Ohio.

Treatment	% Internal Lepidoptera			% Plum curculio		% Tarnished plant bug	% Stink bug	% Leaf-roller (late)	% San Jose Scale	% Woolly apple aphid	% Clean[a]
	Entry[a]	Sting	Total[a]	Oviposition	Late feeding						
Lorsban/Avaunt/ Danitol/Altacor	7.7 B	5.1	12.8 B	7.8	0.3	1.4	0.6	0	0	0	80 A
Altacor/Assail	7.0 B	4.5	11.5 B	7.5	1.0	0.5	2.2	0	0	0	78 A
Closer/Delegate/ Altacor	9.8 B	4.2	14.0 B	7.5	0.5	0	0.2	0	0.2	0	78 A
Mustang/Gladiator/ Beleaf/Delegate	13.5 B	6.0	19.5 B	4.0	0	0.5	1.2	0.2	3.0	0.2	73 A
Mustang/Gladiator/ Mustang/Delegate	15.2 B	7.8	23.0 B	9.5	0.2	1.0	1.5	0	0.2	0.8	67 A
untreated	56.4 A	11.6	68.0 A	7.8	1.8	0.5	0.2	0.2	0.5	0	25 B
Probability (ANOVA)	*<0.0001*	*0.12*	*<0.0001*	*0.22*	*0.47*	*0.53*	*0.21*	*0.60*	*0.68*	*0.58*	*0.0002*

[a] Within each column, means followed by same letter are not significantly different ($P>0.05$); mean separations by LSD. Values shown are actual percentages but ANOVA based on transformed values.

Green apple aphid was abundant in all plots in early summer and showed significant treatment effects on 6/1 (P = 0.0145) when the infestation was lowest in the Closer/Delegate treatment and highest in the Mustang/Gladiator/Mustang treatment (Table 4). Predatory insects that were found in green apple aphid colonies were *Orius insidiosus* adults and nymphs, lady beetle larvae and adults, lacewing larvae and eggs, and *Aphidoletes* larvae; none of these showed significant treatment effects (P > 0.05). Woolly apple aphid was detected in all plots but did not show any significant treatment effects (Table 5). White apple leafhopper was present at negligible levels and did not show any significant treatment effects (Table 6).

Table 4. Green apple aphid: presence or absence of aphids on each of the five endmost leaves on terminal shoots of Delicious apple trees, Columbus, Ohio, 2012.

Treatment	% of terminal leaves infested on three sampling dates		
	5/23	6/1 [a]	6/18
Closer/ Delegate	27	15 C	25
Mustang/ Gladiator/ Beleaf	18	24 BC	24
Altacor	26	38 AB	50
untreated	30	39 AB	52
Lorsban/ Avaunt/ Danitol	17	41 AB	28
Mustang/ Gladiator/ Mustang	30	47 A	44
Treatment effect	*P = 0.27*	*P = 0.0145*	*P = 0.40*

[a] Within each column, means followed by same letter are not significantly different (P>0.05); mean separations by LSD. Values shown are actual percentages but ANOVA based on transformed values.

Table 5. Woolly apple aphid infestation detected on Delicious apple trees, Columbus, Ohio, 2012.

Treatment	% of trees with woolly apple aphid present		
	6/1	6/18	8/1
Lorsban/Avaunt/ Danitol	0	33	0
Altacor	8	33	0
Closer/Delegate	33	58	25
Mustang/ Gladiator/ Beleaf	50	58	17
Mustang/ Gladiator/ Mustang	25	75	17
untreated	33	92	17
Treatment effect	*P = 0.20*	*P = 0.13*	*P = 0.57*

Table 6. White apple leafhopper on fruit clusters and terminal shoots of Delicious apple trees, Columbus, Ohio, 2012.

Treatment	Number of leafhoppers per spur cluster leaf			Number of leafhoppers on endmost five leaves of terminal shoots	
	4/16	4/30	5/9	6/1	6/18
Mustang/ Gladiator/ Beleaf	0.01	0	0	0	0.15
Lorsban/ Avaunt/ Danitol	0	0.01	0	0	0.02
Mustang/ Gladiator/ Mustang	0	0.01	0	0	0
Altacor	0.04	0.01	0	0.05	0.05
Closer/Delegate	0.02	0.02	0.01	0.18	0.18
untreated	0.01	0.05	0	0.08	0.10
Treatment effect	*P = 0.18*	*P = 0.24*	*P = 0.45*	*P = 0.09*	*P = 0.31*

Mites were at low density as they have been in this orchard for the past few years. After mites were detected in untreated plots in early July (Table 6), mites were surveyed in all plots. The European red mite did not show any significant treatment effect on 7/18 (Table 7) or on 8/8 (Table 8). Apple rust mite showed significant treatment effects on 7/18 (Table 7) and on 8/8 (Table 8). Stigmaeids were the most abundant predatory mite and they showed significant treatment effects on both sampling dates; they were more abundant in the Closer/Delegate/Altacor treatment than in other treated plots (Tables 7 and 8).

Table 6. Density of European red mite (ERM) and associated mites on Delicious apples on 7/7/2012.

Treatment	Mean number per leaf		Apple rust mite rating, scale 0-3 [a]	Mean number of predators per leaf	
	ERM motiles	ERM eggs		Stigmaeid motiles	Phytoseiid motiles
Untreated check	0.04	0.05	0.0	0.28	0

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

Table 7. Density of European red mite (ERM) and associated mites on Delicious apples on 7/18/2012.

Treatment	Mean number per leaf		Apple rust mite rating, scale 0-3 [a, b]	Mean number of predators per leaf	
	ERM motiles	ERM eggs		Stigmaeid motiles[b]	Phytoseiid motiles
untreated	0.13	0.04	0.25 B	0.75 A	0
Closer/Delegate/ Altacor	0.09	0.13	0 B	0.39 AB	0
Altacor/Assail	0.01	0.03	0.75 A	0.18 B	0
Mustang/Gladiator/ Mustang/Delegate	0.37	1.07	0.25 B	0.16 B	0.01
Lorsban/Avaunt/ Danitol/Altacor	0.24	0.27	0 B	0.12 B	0
Mustang/Gladiator/ Beleaf/Delegate	0.12	0.21	0 B	0.11 B	0
Treatment effect	*P = 0.40*	*P = 0.44*	*P = 0.0266*	*P = 0.0395*	*P = 0.45*

[a] Density rating scale: 0 = none; 1 = low (<5 per leaf); 2 = moderate (5 to 50 per leaf); 3 = high (>50 per leaf).
[b] Within each column, means followed by the same letter are not significantly different (*P*>0.05), by LSD.

Table 8. Density of European red mite (ERM) and associated mites on Delicious apples on 8/8/2012.

Treatment	Mean number per leaf		Apple rust mite rating, scale 0-3 [a]	Mean number of predators per leaf	
	ERM motiles	ERM eggs		Stigmaeid motiles[b]	Phytoseiid motiles
untreated	0.04	0	0	0.32 A	0
Closer/Delegate/ Altacor	0.05	0.01	0	0.29 AB	0
Altacor/Assail	0.02	0	0	0.03 C	0
Mustang/Gladiator/ Mustang/Delegate	0.09	0.18	0.25	0.05 C	0
Lorsban/Avaunt/ Danitol/Altacor	0.04	0	0	0.09 BC	0
Mustang/Gladiator/ Beleaf/Delegate	0.06	0	0	0.14 ABC	0
Treatment effect	*P = 0.58*	*P = 0.37*	*P = 0.50*	*P = 0.0446*	-

[a] Density rating scale: 0 = none; 1 = low (<5 per leaf); 2 = moderate (5 to 50 per leaf); 3 = high (>50 per leaf).
[b] Within each column, means followed by the same letter are not significantly different (*P*>0.05), by LSD.

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