Apple insect management by insecticides in Ohio, 2013

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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 Closer and Gladiator. Closer is sulfoxaflor, which was registered by Dow in May 2013, for control of plant bugs, aphids, and other sucking pests. Gladiator is a pre-mix of avermectin and zeta-cypermethrin, which was registered by FMC in June 2012 for control of a broad range of pests including mites.

Methods:

The trial was conducted in a 2-acre block of 11-year old apple trees at Ohio State University's Waterman Agricultural and Natural Resources Laboratory in Columbus, Franklin County. There were five 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 and to determine the biofix date, which was 5/9. Treatments for control of first generation codling moth were applied on in the first cover spray on 5/23, which was 250 degree-days after biofix, and again on 6/6 (499 degree-days) and 6/20 (807 degree-days). A fourth cover spray was not needed due to lack of lingering activity of codling moth. For control of second-generation codling moth, insecticides were applied in the fifth cover spray on 7/18, which was 198 degree-days after re-biofix on 7/12, and applied again in the sixth cover spray on 8/1 (497 degree-days) and in the seventh cover spray on 8/15 (802 degree-days). 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. Insecticide products used were esfenvalerate (Asana), chlorpyrifos (Lorsban), zeta-cypermethrin (Mustang Max), sulfoxaflor (Closer), indoxacarb (Avaunt), avermectin plus zeta-cypermethrin (Gladiator), phosmet (Imidan), chlorantraniliprole (Altacor), spinetoram (Delegate), and acetamiprid (Assail). Formulations and rates used, and the sequence of product combinations, are shown in Table 1.

Table 1. Sequence and rates of products applied in apple insecticide trial, Columbus, Ohio, 2013.

Treat-ment	Pink bud on 4/23/13	Petal-fall on 5/9/13	1C on 5/23/13 (250 DD after biofix)	2C on 6/6/13 (499 DD) & 3C on 6/20/13 (807 DD)	5C on 7/18/13 (198 DD) & 6C on 8/1/13 (497 DD) & 7C on 8/15/13 (802 DD)
1 Dupont	Asana XL 0.66EC, 9.6 fl oz/A	Avaunt 30WDG, 6 oz/A	Altacor 35WG, 3 oz/A	Altacor 35WG, 3 oz/A	Assail 30SG, 6 oz/A, + oil 0.5%
2 FMC	Mustang Max 0.8EC, 4 fl oz/A	Gladiator 0.33EW, 18 fl oz/A, + oil 0.5%	Gladiator 0.33EW, 18 fl oz/A, + oil 0.5%	Altacor 35WG, 3 oz/A	Delegate 25WG, 5.2 oz/A
3 Dow	Closer 2SC, 3 fl oz/A	Imidan 70WP, 3 lb/A	Delegate 25WG, 5.2 oz/A	Delegate 25WG, 5.2 oz/A, + Closer 2SC, 1.5 fl oz/A in 2C for GAA	Delegate 25WG, 5.2 oz/A
4 standard	Lorsban 50W, 3 lb/A	Avaunt 30WDG, 6 oz/A	Imidan 70WP, 3 lb/A	Imidan 70WP, 3 lb/A	Imidan 70WP, 3 lb/A
5 untreated	-	-	-	-	-

For fruit thinning, Sevin XLR Plus at 1 qt/A and MaxCel at 75 ppm were applied on 5/16. For disease control, Captec 4L at 1 qt/A was used at pink on 4/23, at 1.5 qt/A at early petalfall on 5/2 and on 5/14 and 5/28, at 1 qt/A on 6/11, 6/25, 7/23, and 8/6. Thinners and fungicides were applied on all trees, including checks, by an AgTech 4002 airblast sprayer operated at pressure of 20 psi, with TeeJet 6510 and 6520 nozzle tips.

Insect injury was evaluated on 100 randomly selected fruit from the center of each plot, non-destructively on 7/3, and destructively at harvest from 9/17 to 9/26. Rosy apple aphid was evaluated in each of three trees per plot by counting the number of infested clusters in middle zone of the canopy in a 1-minute search per tree on 5/21. 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 6/5, 6/14, and 6/19; the number of predatory insects was also recorded. Woolly apple aphid infestation was evaluated by scouting its presence or absence in a one-minute search per tree in one tree per plot on 6/5 and in three trees per plot on 6/14 and 6/19.

Mite populations were sampled on 7/10. 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 9.3 microcomputer statistics program. Percentage data were transformed by arcsine square root before analysis.

Results and Discussion:

Bud development was about 3 weeks later than normal. Codling moth pressure was high as indicated by large trap counts (Fig. 1); traps detected sustained flight on 5/9/2013, which was used as the biofix date. Lesser appleworm was also present; oriental fruit moth was absent.

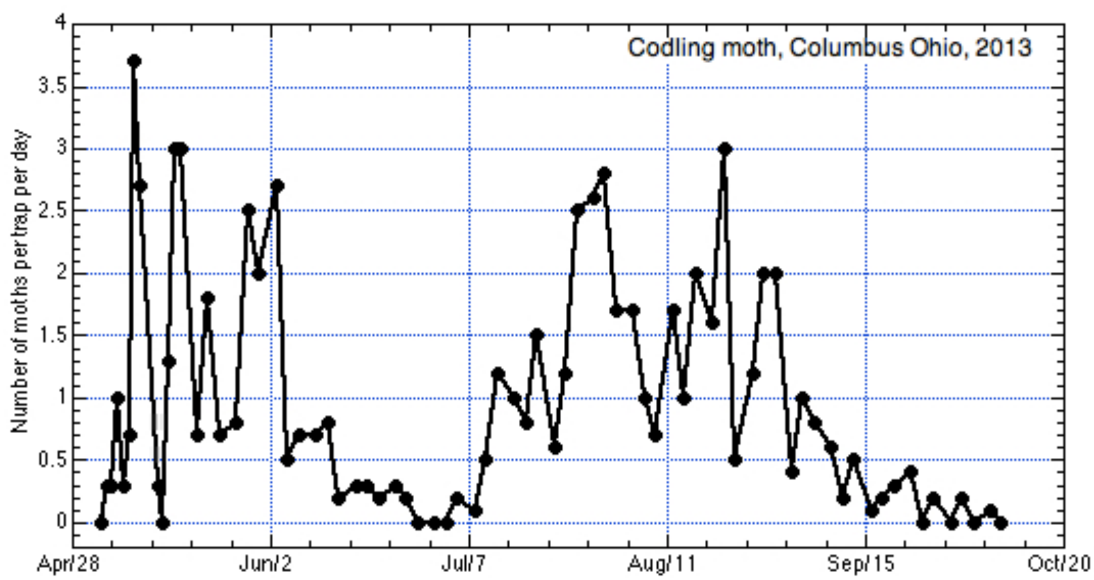

Figure 1. Seasonal trends in the adult population of codling moth as detected by pheromone trap captures in apples at Waterman Orchard, Columbus, Ohio, 2013; mean of three traps.

The percentage of fruit damaged by codling moth or other internal Lepidoptera in early July, which reflects control of first generation codling moth, was significantly lower in all four insecticide treatments than in untreated plots (P = 0.0036; Table 2). The percentage of fruit that was clean of any insect damage was significantly higher in plots treated with Closer at pink followed by Delegate for first generation codling moth and in plots treated with Lorsban at pink followed by Imidan for first generation codling moth (P = 0.0039; Table 2), both of which reflect the difference in rosy apple aphid control by products applied at pink. The infestation of rosy apple aphid was severe, and the worst ever seen in this orchard. Other insects that caused damage to fruit by early July were San Jose scale, tarnished plant bug, plum curculio, woolly apple aphid, and stink bugs, but none of these differed significantly among treatments (Table 2).

Damage by codling moth in September, which reflects control of the second generation of codling moth, was significantly less in plots treated with Altacor for first generation and Assail for second generation, and in plots treated with Gladiator followed by Altacor for first generation and Delegate for second generation, than in plots treated with Imidan for both generations or Delegate for both generations; these latter two treatments were not different or worse than the untreated control (P < 0.0001; Table 3). This result of heavy damage in Delegate and Imidan plots is surprising and difficult to explain. Other insects that caused much damage to fruit were rosy apple aphid, stink bugs, and San Jose scale. Rosy apple aphid showed the same trends as in the July evaluation, with the best control in plots that were treated with Closer or Lorsban at the pink bud stage (P < 0.0001; Table 3). Stink bug damage was significantly less than untreated plots when treated with Delegate or Imidan in the fifth, sixth, and seventh cover sprays (P = 0.0218, Table 3). San Jose scale was abundant but did not differ significantly among treatments (P = 0.71, Table 3). Other insects that caused damage but were less abundant were tarnished plant bug, plum curculio, and leafrollers, and, but none of these varied significantly among treatments (Table 3). A complicating factor was that corkspot was common in some trees (Table 3), which required slower evaluation to distinguish it from stink bug damage. No apple maggot was detected. No phytotoxicity was observed.

Rosy apple aphid colonies on 5/21 were less abundant in plots treated with Closer or Lorsban at the pink bud stage on 4/23 than in plots treated with Asana or untreated; plots treated with Mustang Max were intermediate (P < 0.0001, Table 4).

Green apple aphid was abundant in all plots. Scouting of terminal shoots on 6/5 showed significantly lower infestation of green apple aphid in plots treated with Mustang at pink followed by Gladiator at petalfall and first cover (Table 5). This shifted by 6/14 when green apple aphid infestation was significantly less where Closer was sprayed at second cover on 6/6. By 6/19, aphid infestation had dropped sharply in plots treated with Closer or in untreated plots (Table 5). Predatory insects that were found in green apple aphid colonies were lady beetles (larvae and adults), which were significantly higher in untreated plots than in all insecticide plots (P = 0.0031, Table 6), and *Aphidoletes* larvae which were significantly higher in Mustang/Gladiator plots and in Lorsban/Imidan plots (P < 0.0001, Table 6). *Orius insidiosus* adults and nymphs, and lacewing larvae and eggs, were also found but did not show significant treatment effects (P > 0.05, Table 6).

Woolly apple aphid was detected in early summer and showed significant treatment effects, with lower infestations where Lorsban or Closer had been used at the pink bud stage (Table 7). By 6/19, infestation had fallen in the untreated control but was high in plots treated with Mustang or Asana.

Mites were at low density, as they have been in this orchard for the past few years. In early July, there was only a trace of European red mite, which did not show any significant treatment effect (Table 8). Apple rust mite was absent in all samples. Stigmaeids were the most abundant predatory mite but they did not show a significant treatment effect; they were most abundant in the untreated plots and least abundant in Mustang/Gladiator plots (Table 8). Phytoseiid predatory mites were found only in the Lorsban/Imidan treatment (Table 8).

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Table 2. Insect injury to apple fruit after treatment by five management programs, evaluated non-destructively on 3 July 2013; mean of four blocked replicates at OSU's Waterman Lab, Columbus, Ohio.

Treatment (pink/ codling moth 1st generation)	% Internal Lepidoptera			% Rosy apple aphid[a]	% Stink bug	% San Jose Scale	% Tar-nished plant bug	% Plum cur-culio	% Woolly apple aphid	% Clean[a]
	Entry[a]	Sting	Total[a]							
Closer/Delegate	0.8 BC	0.5	1.2 B	5.1 C	0.7	5.2	0.2	0.5	0.0	87 A
Asana/Altacor	1.5 BC	1.2	2.8 B	35.8 B	1.0	0.8	1.2	0.5	0.2	59 BC
Lorsban/Imidan	2.0 B	0.8	2.8 B	5.8 C	0.0	10.4	0.5	0.2	0.0.	81 AB
Mustang/Gladiator	0.8 C	2.8	3.5 B	32.1 B	0.8	1.2	0.0	0.5	1.6	61 B
untreated	9.5 A	1.8	11.3 A	58.6 A	0.0	3.8	1.7	0.0	0.0	32 C
Probability (treatment effect)	*0.0002*	*0.79*	*0.0036*	*<0.0001*	*0.49*	*0.82*	*0.29*	*0.72*	*0.44*	*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 five insecticide programs, evaluated destructively at harvest on 17-26 September 2013; mean of four blocked replicates at OSU's Waterman Lab, Columbus, Ohio.

Treatment (codling moth 1st generation/ 2nd generation)	% Internal Lepidoptera			% Rosy apple aphid[a]	% Stink bug[a]	% San Jose scale	% Tarn-ished plant bug	% Plum curculio		% Leaf-roller	% Clean of insect dam-age	% Cork-spot[a]
	Entry[a]	Sting[a]	Total[a]					Ovi-posi-tion	Late feed-ing			
Altacor/Assail	2.5 B	3.0 B	5.5 C	22.4 B	27.9 ABC	3.0	0.7	49 A	0.5	0.2	49 A	42.3 AB
Gladiator,Altacor/ Delegate	5.5 B	6.0 B	11.5 C	27.6 B	36.9 AB	19.4	0.2	27 B	0	0	27 B	24.8 BC
Imidan/ Imidan	14.5 A	19.0 A	33.4 AB	1.2 C	18.6 BC	19.7	0.2	41 A	0	0.8	41 A	43.2 AB
Delegate/ Delegate	19.0 A	15.7 A	34.7 A	2.8 C	11.9 C	34.1	0.2	35 A	0	0	35 A	53.7 A
untreated	20.6 A	2.0 B	22.7 B	72.3 A	48.4 A	12.7	2.2	6 B	0.2	0.5	6 B	18.4 C
Probability (treatment effect)	*<0.0001*	*0.0003*	*<0.0001*	*<0.0001*	*0.0218*	*0.71*	*0.34*	*0.0298*	*0.60*	*0.45*	*0.0298*	*0.0293*

[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 4. Rosy apple aphid (RAA) in Delicious apple trees, Columbus, Ohio, 21 May 2013.

Treatment (pink / petalfall)	Number[a] of RAA-infested clusters in middle zone of canopy in 1-minute search
Lorsban / Avaunt	1.0 C
Closer / Imidan	1.0 C
Asana / Avaunt	7.3 BC
Mustang / Gladiator	12.9 B
untreated	29.1 A
Probability (treatment effect)	*P < 0.0001*

[a] Within each column, means followed by same letter are not significantly different (*P*>0.05); mean separations by LSD.

Table 5. Green apple aphid on terminal shoots of Delicious apple trees, Columbus, Ohio, 2013.

Treatment (pink/ codling moth 1st generation)	Percentage[a] of terminal leaves infested on three sampling dates		
	6/5	6/14	6/19
Closer/Delegate	90 A	44 C	10 B
Asana/Altacor	88 A	99 A	58 A
Lorsban/Imidan	93 A	95 AB	80 A
Mustang/Gladiator,Altacor	65 B	94 AB	90 A
untreated	96 A	66 BC	2 B
Probability (treatment effect)	*P = 0.0005*	*P = 0.0138*	*P = 0.0003*

[a] Within each column, means followed by same letter are not significantly different (*P*>0.05); mean separations by LSD.

Table 6. Predators associated with green apple aphid on Delicious apple trees, Columbus, Ohio, 2013.

Treatment (pink/ codling moth 1st generation)	Number [a] of predators on endmost 5 leaves of terminal shoot					
	Orius on 6/5	Orius on 6/14	Lady beetles on 6/14	Lacewing larvae on 6/14	Lacewing larvae on 6/19	Orange midge, *Aphidoletes aphidimyza* on 6/19
Closer/Delegate	0.08	0.08	0.20 B	0.18	0	0.02 C
Asana/Altacor	0.08	0.08	0.05 B	0.02	0.15	3.65 B
Lorsban/Imidan	0.05	0.10	0.02 B	0	0.08	7.10 A
Mustang/Gladiator,Altacor	0.20	0.18	0.00 B	0	0.12	9.42 A
untreated	0.08	0	0.85 A	0.38	0	0.00 C
Probability (trt effect)	*P = 0.19*	*P = 0.35*	*P = 0.0031*	*P = 0.41*	*P = 0.44*	*P < 0.0001*

[a] Within each column, means followed by same letter are not significantly different (*P*>0.05); mean separations by LSD.

Table 7. Woolly apple aphid (WAA) infestation detected on Delicious apple trees, Columbus, Ohio, 2013.

Treatment (pink/ codling moth 1st generation)	Presence or absence of WAA (0 = absent; 1 = present) on three sampling dates		
	6/5 (1 sample per plot)	6/14 (3 samples per plot)	6/19 (3 samples per plot)
Lorsban/Imidan	0.0 C	0.1 B	0.0 B
Closer/Delegate	0.2 BC	0.3 B	0.0 B
Asana/Altacor	1.0 A	1.0 A	0.8 A
Mustang/ Gladiator,Altacor	0.8 AB	1.0 A	1.0 A
untreated	0.2 BC	0.8 A	0.1 B
Probability (treatment effect)	*P = 0.0156*	*P = 0.0004*	*P < 0.0001*

Table 8. Density of European red mite (ERM) and associated mites on Delicious apple leaves on 10 July 2013, Columbus, Ohio.

Treatment (pink/ codling moth 1st generation)	Mean number per leaf		Apple rust mite rating[a]	Mean number of predators per leaf	
	ERM motiles	ERM eggs		Stigmaeid motiles	Phytoseiid motiles
Closer/Delegate	0.02	0	0	0.7	0
Lorsban/Imidan	0	0	0	0.4	0.01
Asana/Altacor	0.06	0.13	0	0.2	0
Mustang/ Gladiator,Altacor	0	0	0	0.1	0
untreated	0	0	0	0.8	0
Probability (trt effect)	*P = 0.54*	*P = 0.44*	-	*P = 0.14*	*P = 0.44*

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