

Codling moth management by insecticides in Ohio apple orchards, 2009

Final report to DuPont, Syngenta, and Bayer, 12/28/2009

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Introduction: New insecticides were evaluated for control of codling moth, which is challenging in some Ohio orchards due to resistance to organophosphate insecticides. Efficacy of the recently registered products Altacor (chlorantraniliprole), Belt (flubendiamide), and Voliam Flexi (chlorantraniliprole + thiomethoxam) were evaluated in combination with Assail (acetamiprid), Calypso (thiacloprid), Proclaim (emamectin benzoate), Leverage (cyfluthrin + imidacloprid), and the standard organophosphate Imidan (phosmet). The use of a pyrethroid (cyfluthrin) in late summer was included despite its known harshness to natural enemies. This is the seventh year that codling moth evaluations have been conducted at this site.

Methods:

The trial was conducted in a block of 7-year old apple trees at Ohio State University's Waterman Laboratory in Columbus, Franklin County, Ohio. There were six treatments, each with four replicates in a randomized complete block design. There were seven adjacent Red Delicious trees per plot. There was a guard row of Golden Delicious, Gala, and Fuji between adjacent treatment rows.

The trap-based codling moth biofix was 5/11. Treatments for control of first generation codling moth were applied on 5/26, which was 232 degree-days after biofix, and again on 6/9 (470 degree-days). For control of second-generation codling moth, insecticides were applied on 7/14, which was 1200 degree-days after biofix, and again on 7/28 (1476 degree-days) and 8/11 (1786 degree-days). Only two sprays had been planned for control of second generation, but a third spray was added after a late surge in codling moth adult activity (Fig. 1). 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 for control of codling moth were Altacor 35WG (3 oz/A), Assail 30SG (5 oz/A) plus oil (PureSpray, 0.5%), Calypso 4F (6 fl oz/A), Proclaim 5SG (4.8 oz/A), Imidan 70WP (3 lb/A), Belt 4SC (5 fl oz/A), Voliam Flexi (6 oz/A), and Leverage 2.7SE (5.1 fl oz/A). The sequence of product combinations is shown in Table 1.

For control of San Jose scale and mites, oil (Damoil, 1%) was applied in all plots at tight cluster on 4/2. For control of rosy apple aphid at pink on 4/16, Calypso 4F (4 fl oz/A) and chlorpyrifos (Lorsban 50WG, 3 lb/A) were used in some plots as shown in Table 1. For control of plum curculio and other pests at petal-fall on 5/1, Guthion 50WP (2 lb/A) + Movento 2SC (9 fl oz/A) + LI-700 (0.5%), Actara 25WDG (4.5 oz/A), and indoxacarb (Avaunt 30WDG, 6 oz/A) were applied to some plots as shown in Table 1. Due to unusually slow emergence of codling moth, an extra spray of Imidan (3 lb/A) was applied on 5/14, between petal-fall and first cover, to all plots except the untreated check. Between generations of codling moth, at third cover on 6/23, Imidan was applied to all plots except the untreated check. In the fourth and fifth cover sprays in the Belt treatment, Provado + NuFilm 17 were added for apple maggot control. For mite control in all plots, including checks, Acramite 50WS (1 lb/A) was applied on 6/2 and Nexter 75WP (4.4 oz/A) was applied on 7/9. For disease control, Dithane Rainshield was used on 3/31 (half-inch green), Dithane Rainshield + Nova was used on 4/16 (pink), Dithane Rainshield + AgriStrep was used on 4/24 (bloom); Dithane Rainshield was used on 5/1 (petal-fall) and 5/12 (first cover); Ziram 76DF was applied on 6/2, 6/16, 7/9, 7/21, and 8/4; and Captan 80WDG was applied on 8/20 and 9/1. For fruit thinning, MaxCel (100 ppm) and Sevin XLR Plus (1 qt/A) were applied on 5/7, and NAA (5 ppm) plus Induce (0.7 pt/A) were applied on 5/20. A foliar spray of Miller's Nutrileaf 20-20-20 (3 lb/A) was applied on 5/1. Fungicides, thinners, nutrients, and miticides 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 7/7, and destructively at harvest on 9/17. 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:

Both codling moth and lesser appleworm were present (Fig. 1); oriental fruit moth was absent. The percentage of fruit damaged by internal Lepidoptera was significantly lower in all five insecticide treatments than in the untreated check in July, which reflects control of first generation ($P = 0.01$; Table 2), and in September, which reflects control of the second generation ($P = 0.001$; Table 3). Among the five insecticide programs, there were no significant differences in internal Lepidoptera in July (Table 2), whereas in September, there were significant differences in entries and stings, but no differences in the total damage by internal Lepidoptera (Table 3). Other insects that caused damage to fruit were plum curculio, tarnished plant bug, and leafrollers (Tables 2 and 3). No apple maggot was detected. Assail for first generation control followed by Altacor for second generation control was identical to the opposite sequence of Altacor for first generation control followed by Assail for second generation control in terms of internal Lepidoptera, but Assail followed by Altacor was significantly better for management of the full insect pest complex (Table 3). All five insecticide programs resulted in significantly more clean fruit than the untreated check (Table 3). The highest percentage of clean fruit was in the Assail/Altacor treatment, which was significantly higher than the Calypso/Belt treatment, while the Proclaim/Voliam Flexi, Imidan/Imidan, and Altacor/Assail treatments were intermediate. No phytotoxicity was observed.

Acknowledgements: Technical assistance from Mark Schmittgen, Glenn Mills, Gretchen Sutton, Nick Weidenbenner, Michelle LaCount, and Marie Burleson was greatly appreciated. Funding and products were supplied by DuPont, Syngenta, and Bayer. Products supplied by United Phosphorus and Gowan were also appreciated.

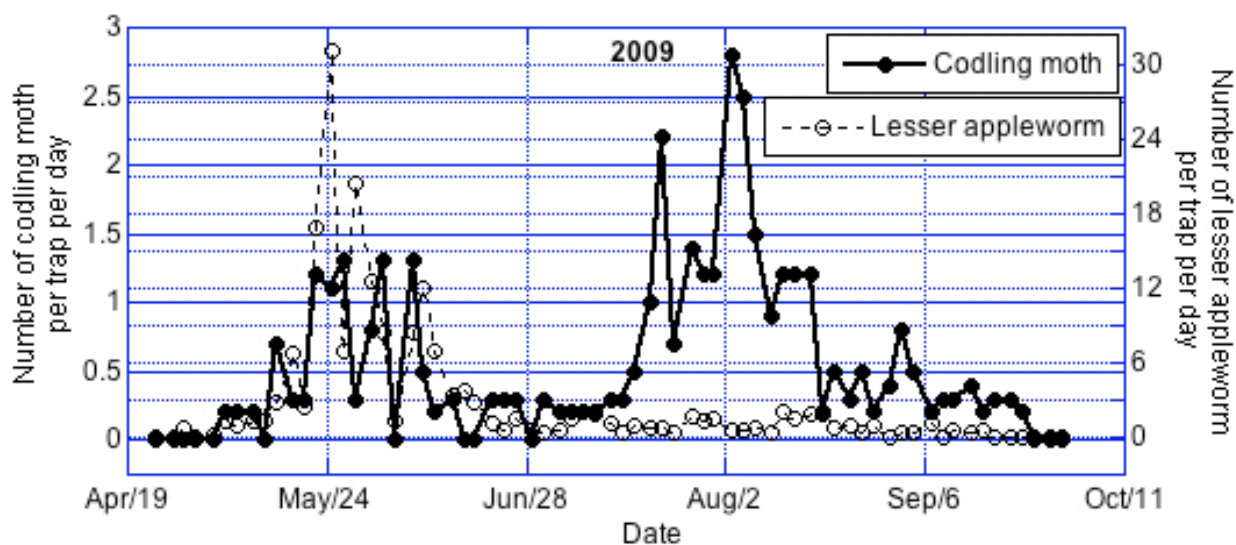


Figure 1. Seasonal trends in codling moth and lesser appleworm adult populations as detected by pheromone traps in apple orchards at Waterman Lab, Columbus, Ohio, 2009.

Table 1. Sequence of insecticide sprays in experimental plots of apples, Columbus, Ohio, 2009.

No.	Tight cluster (4/2)	Pink (4/16)	Petalfall (5/1)	Pre-1 st cover	1 st cover (5/26), 2 nd cover (6/9)	3 rd cover (6/23)	4 th cover (7/14), 5 th cover (7/28), 6 th cover (8/11)	7 th cover (8/25)
1	oil	Lorsban	Avaunt	Imidan	Altacor	Imidan	Assail	Imidan
2	oil	Lorsban	Avaunt	Imidan	Assail	Imidan	Altacor	Imidan
3	oil	Calypso 4 oz	Guthion+ Movento + LI-700	Imidan	Calypso 6 oz	Imidan	Belt + Provado + Nu-Film	Leverage
4	oil	Lorsban	Actara	Imidan	Proclaim	Imidan	VoliamFlexi	Imidan
5	oil	Lorsban	Avaunt	Imidan	Imidan	Imidan	Imidan	Imidan
6	oil	-	-	-	-	-	-	-

Table 2. Insect injury to apple fruit after treatment by six insecticide programs, evaluated non-destructively on 7 July 2009; mean of four blocked replicates at OSU's Waterman Lab, Columbus, Ohio.

Treatment	% Internal Lepidoptera			% Plum curculio, oviposition	% Tarnished plant bug	% Leafroller	% Clean ^a
	Entry ^a	Sting	Total ^a				
Proclaim	0 B	0	0 B	1.5	0.8	0.0	97.8 A
Imidan	0 B	0	0 B	1.8	1.0	0.0	97.2 A
Altacor	0 B	0	0 B	4.0	0.8	0.0	95.2 AB
Assail	0.2 B	0	0.2 B	1.0	0.5	0.0	98.2 A
Calypso	0.2 B	0	0.2 B	1.5	1.0	0.2	97.0 A
untreated	4.5 A	0.2	4.8 A	6.2	1.0	0.5	87.8 B
<i>probability</i>	<i>P=0.01</i>	<i>P=0.45</i>	<i>P=0.01</i>	<i>P=0.16</i>	<i>P=0.96</i>	<i>P=0.60</i>	<i>P=0.02</i>

^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 insecticide programs, evaluated destructively at harvest, 17 September 2009; mean of four blocked replicates at OSU's Waterman Lab, Columbus, Ohio.

Treatment	% Internal Lepidoptera			% Plum curculio, ovi-position	% Plum curculio, late feeding ^a	% Tarnished plant bug	% Leaf-roller ^a	% Clean ^a
	Entry ^a	Sting ^a	Total ^a					
Assail/Altacor	0.8 BC	0.2 C	1.0 B	1.8	0.0 B	0.5	0.0 B	97.0 A
Altacor/Assail	0.8 BC	0.2 C	1.0 B	3.0	0.0 B	2.0	0.0 B	94.0 BC
Proclaim/VoliamFlexi	0.2 C	1.2 AB	1.5 B	0.2	0.0 B	1.5	0.2 B	96.5 AB
Imidan/Imidan	1.5 BC	0.5 BC	2.0 B	2.2	0.0 B	0.8	0.0 B	95.0 ABC
Calypso/Belt	3.5 B	1.0 BC	4.5 B	1.8	0.0 B	1.5	0.2 B	92.2 C
untreated	13.8 A	2.5 A	16.2 A	4.8	2.2 A	2.0	1.5 A	75.0 D
<i>probability</i>	<i>0.0008</i>	<i>0.01</i>	<i>0.001</i>	<i>0.11</i>	<i>0.002</i>	<i>0.35</i>	<i>0.01</i>	<i><0.0001</i>

^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.