Ohio Trial on Codling Moth Control in Apples, 2003

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Background

Codling moth has become difficult to control in some Ohio apple orchards during the past few years. In 2002, codling moth damage was extremely high (10 to 60%) in some orchards, although there was negligible economic damage in most orchards. The reason for the severe problem in some orchards is not known, but resistance to organophosphates is suspected as part of the problem. Other factors that might have contributed to the problem were unusually high codling moth populations that were active over an unusually long period of time, along with possible inadequate rates and inadequate spray coverage. New regulations have limited the amount of organophosphates that can be used, so that even at orchards where organophosphates are working well, other insecticides are needed for full-season control of pests. Growers know that non-organophosphate insecticides are becoming available but these are generally less reliable and more expensive than organophosphates. Growers need research data on which of the new insecticides are the best replacements for organophosphates. This project was done in conjunction with similar trials in Kentucky, Indiana, Illinois, and Missouri as part of a 5-State effort to test for variability among codling moth populations in susceptibility to insecticides. The objective of this trial was to determine which insecticides are most effective for codling moth control in Ohio.

Methods

A field trial was done in small plots in a block of 18-year old Melrose apples at OSU's Waterman Laboratory in Franklin County, central Ohio. Codling moth control had been poor the previous year at this site. There were nine treatments each with four replicates in a randomized complete block design, with three adjacent trees per plot. Treatments targeted first generation codling moth larvae. Treatments were applied three times regardless of whether this exceeded recommended or registered use. Timing of the first spray was intended at approximately 150 degree-days (base 50ºF) after sustained flight of codling moth, followed by two sprays at 14-day intervals. Insecticide treatments were applied by a hand-gun sprayer with a dilute volume of 150 gal/A.

Insecticides were applied at their maximum rates. Treatments were the registered insecticides Assail 70WP (acetamiprid) at 3.4 oz/A, Avaunt 30WDG (indoxacarb) at 6 oz/A, Danitol 2.4EC (fenpropathrin) at 21 fl oz/A, Esteem 35WP (pyriproxyfen) at 5 oz/A, Imidan 70WP (phosmet) at 4 lb/A, and Intrepid 2SC (methoxyfenozide) at 16 fl oz/A, as well as the unregistered insecticides Calypso 4F (thiacloprid) at 6 fl oz/A, and Diamond 7.5WG (novaluron) at 39.75 oz/A, and an untreated check. Late first-generation and second generation codling moth were treated with uniform program of Imidan 70WP at 3 lb/A five times, on 6/20, 7/3, 7/18, 8/1, and 8/20, on all plots except the untreated checks. A uniform fungicide program was used in all plots including untreated checks.

Pheromone traps were used to monitor adult populations of codling moth as well as lesser appleworm and oriental fruit moth. Three Pherocon-VI sticky traps with long-life lures made by Trécé were used for codling moth, with lures changed every 8 weeks. A single Multi-Pher trap was used for each of lesser appleworm and oriental fruit moth with standard 4-week lures made by Trécé. The date of sustained flight of codling moth was used as a biofix to start a degree-day count on which insecticide timing was based.

Biofix of codling moth in pheromone traps was 1 May. Insecticide treatments were applied on 8 May at 113 degree-days (DD) after biofix, on 22 May at 287 DD, and 5 June at 436 DD. The first spray was applied earlier than the target of 150 degree-days due to the weather forecast for several rainy days at the predicted time of 150 degree-days.

Damage by internal Lepidoptera larvae was evaluated on fruit in the center of each plot non-destructively on 3 July to evaluate first generation damage, and destructively at harvest on 18 September to evaluate second generation damage. Foliar pests sampled for tratment effects were white apple leafhopper on 16 May, 28 May, and 30 June, and European red mite on 16 June. Data were analyzed by analysis of variance with means separated by LSD tests. Angular transformation was used on percentage data before analysis.

Results

Pheromone traps showed that codling moth began sustained flight on 1 May, the first flight peaked on 14 May with a mean of 55.7 moths per trap per week, and the second flight peaked on 20 August with a mean of 50.0 moths per trap per week (Table 1). Oriental fruit moth was barely detectable at this orchard. Lesser appleworm had a large first generation that peaked at 55 moths per week on 21 May, and a small second generation that did not have a clear peak date (Table 1).

The untreated treatment showed that pressure from codling moth was intense; 16.5% of fruit were damaged by early July (Table 2) and 49.0% by September (Table 3). All eight insecticide treatments worked equally well and were significantly better than the untreated check when evaluated in early July (Table 2), but significant treatment differences were detected at harvest in September (Table 3). Codling moth control was significantly better by Diamond (5.0% damage) than by Esteem (25.3% damage), Danitol (17.0% damage), and Imidan (14.2% damage). Two other pests that showed significant treatment effects at harvest were San Jos□é scale and late leafrollers. Damage was detected but with no treatment differences by plum curculio, tarnished plant bug, and apple maggot (Table 3).

The density of white apple leafhopper nymphs on 16 May was significantly lower in all treatments except Diamond, and on 28 May was not different among treatments (Table 4). Leafhopper damage ratings on 30 June showed least damage in Assail plots, and the most damage in Esteem and Diamond plots. Leafhopper damage in Calypso, Avaunt, and Danitol plots was not significantly different than in Assail plots.

European red mite, apple rust mite, and phytoseiid mites did not show any treatment effect by 16 June (Table 5). There was a significant effect on stigmaeid mites, with significantly more stigmaeids in the untreated check, Imidan, Calypso, and Diamond treatments than in other treatments.

Discussion

Codling moth control by Imidan was better in 2003 than in 2002 at this site, possibly due to earlier timing than in the previous year and due to higher rates used. Weather in 2003 was cooler and rainier than usual. This weather was possibly less conducive to codling moth survival, however, high numbers of moths caught in pheromone traps suggest that the population pressure was very high despite the weather.

The lack of differences among insecticides in the early July evaluation but presence of significant differences in the September evaluation was surprising considering that a uniform program of Imidan was used in all plots starting in late June. A possible reason for this could be that the July evaluation was done before all first generation damage had become visible. Control from all products would likely be better when used in larger plots and not close to untreated check plots that served as a refuge for codling moth.

In conclusion, this trial showed that codling moth control by Imidan can be fair even at a site where it had performed poorly the previous year, and most of the newer non-organophosphate insecticides provided good control. Now that data has been obtained on performance of single insecticides, the next step will be to look at several combinations of insecticides for best control of the first and second generations of codling moth.

Table 1. Weekly counts of moths in pheromone traps, and degree-day accumulations, at OSU's Waterman Lab, Columbus Ohio, 2003.

Date	Trap counts			Cumulative degree-days[1] after biofix for codling moth on 5/1/03
	Codling moth (mean of 3 traps in apple blocks)	Lesser appleworm (one trap in apple block)	Oriental fruit moth (one trap in adjacent peach block)	
4/2	–	–	0	–
4/9	–	–	0	–
4/16	–	–	0	–
4/23	0.0	–	3	–
4/30	1.7	10	2	–
5/7	46.3	38	0	97
5/14	55.7 (peak)	46	0	192
5/21	22.7	55 (peak)	0	278
5/28	10.0	24	0	354
6/4	16.0	10	0	427
6/11	22.7	22	0	549
6/18	19.7	29	0	694
6/25	17.0	8	0	824
7/2	6.7	16	0	994
7/9	2.0	10	0	1188
7/16	11.0	4	0	1339
7/23	19.7	4	0	1486
7/30	20.0	7	0	1637
8/6	35.0	8	0	1796
8/13	27.3	5	0	1962
8/20	50.0 (peak)	3	0	2138
8/27	18.0	3	1	2314
9/3	9.3	2	0	2472
9/10	5.7	4	0	2593
9/17	5.7	1	0	2718
9/24	6.0	0	–	2812
10/1	1.7	0	–	2862

[1] Degree-days calculated as mean of daily maximum and minimum temperature, base 50F, with 50F substituted for true minimum if true minimum less than 50F.

Table 2. Damage to Melrose apple fruit by 3 July 2003, at end of codling moth's first generation, at OSU's Waterman Lab, Columbus, Ohio; mean of 4 replicates, N = 100 fruit per plot.

Treatment	*% of fruit injured by internal Lepidoptera*
Untreated check	16.5 A
Esteem 35WP, 5 oz/A	2.2 B
Assail 70WP, 3.4 oz/A	2.0 B
Intrepid 2SC, 16 fl oz/A	1.8 B
Calypso 4F, 6 fl oz/A	1.5 B
Diamond 7.5WG, 39.75 oz/A	1.0 B
Imidan 70WP, 4 lb/A	1.0 B
Avaunt 30 WDG, 6 oz/A	0.8 B
Danitol 2.4EC, 21 fl oz/A	0.2 B
P value (trtmt effect)	*0.0001*

Means shown are actual percentages but statistics are based on transformed values.

Table 3. Insect damage to Melrose apple fruit at final harvest on 18 September 2003 at OSU's Waterman Lab, Columbus, Ohio; mean of 4 replicates, N = 100 fruit per plot.

Treatment	*% of fruit injured by insects*							*% clean*
	Internal Lepidoptera	*San José scale*	*Plum curc. ovip.*	*Plum curc. late*	*Tarn. plant bug*	*Leaf-roller*	*Apple maggot*	
Untreated check	49.0 A	2.5 AB	0.5	0.2	0.2	2.0 A	0	48 D
Esteem 35WP, 5 oz/A	25.3 B	0.0 C	0.2	0	0	0.2 B	0.2	74 C
Danitol 2.4EC, 21 fl oz/A	17.0 BC	1.0 BC	0.5	0	0	0.0 B	0	82 BC
Imidan 70WP, 4 lb/A	14.2 BC	1.2 BC	0.2	0	0.2	0.5 B	0.2	85 ABC
Calypso 4F, 6 fl oz/A	11.2 CD	0.0 C	0.2	0.2	0.2	0.8 B	0	87 AB
Avaunt 30 WDG, 6 oz/A	10.8 CD	7.5 A	0.8	0.2	0	0.0 B	0	82 BC
Intrepid 2SC, 16 fl oz/A	7.8 CD	1.2 BC	0.5	0	0	0.0 B	0	90 AB
Assail 70WP, 3.4 oz/A	6.5 CD	0.0 C	0.2	0	0	0.2 B	0	93 A
Diamond 7.5WG, 39.75 oz/A	5.0 D	1.8 ABC	1.8	0	0	0.5 B	0	92 AB
P value (trtmt effect)	*0.0001*	*0.01*	*0.52*	*0.46*	*0.63*	*0.01*	*0.58*	*0.0001*

Means shown are actual percentages but statistics are based on transformed values.

Table 4. White apple leafhopper density and damage rating on Melrose apple leaves in 2003 at OSU's Waterman Lab, Columbus, Ohio; mean of four replicates.

Treatment	*Number of leafhopper nymphs per leaf on two sampling dates*		*Damage rating[1] on 6/30 (25 days after 3rd codling moth spray)*
	5/16 (8 days after 1st codling moth spray)	*5/28 (6 days after 2nd codling moth spray)*	
Esteem 35WP, 5 oz/A	0.04 BC	0.16	0.85 A
Diamond 7.5WG, 39.75 oz/A	0.06 AB	0.10	0.73 AB
Untreated check	0.09 A	0.15	0.63 ABC
Imidan 70WP, 4 lb/A	0.00 C	0.06	0.48 BC
Intrepid 2SC, 16 fl oz/A	0.03 BC	0.05	0.40 CD
Danitol 2.4EC, 21 fl oz/A	0.00 C	0.00	0.20 DE
Avaunt 30 WDG, 6 oz/A	0.01 C	0.01	0.20 DE
Calypso 4F, 6 fl oz/A	0.00 C	0.00	0.16 DE
Assail 70WP, 3.4 oz/A	0.00 C	0.00	0.06 E
P value (trtmt effect)	*0.0008*	*0.06*	*0.0001*

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

Table 5. Mite density on Melrose apple leaves on 16 June 2003 (11 days after third codling moth spray) at OSU's Waterman Lab, Columbus, Ohio; mean of four replicates. Note, Vydate (4 pts/A) was used in entire block at pink on 16 April 2003.

Treatment	*Number per leaf*				*Rating[1]*
	European red mite		*Predatory mites*		*Apple rust mite*
	motiles	*eggs*	*Stigmaeid motiles*	*Phytoseiid motiles*	
Imidan 70WP, 4 lb/A	0.26	0.82	0.08 AB	0.00	2.8
Esteem 35WP, 5 oz/A	0.22	0.42	0.00 C	0.00	2.5
Intrepid 2SC, 16 fl oz/A	0.14	0.96	0.00 C	0.02	2.8
Avaunt 30 WDG, 6 oz/A	0.12	0.16	0.00 C	0.00	3.0
Calypso 4F, 6 fl oz/A	0.04	0.15	0.02 BC	0.02	2.5
Assail 70WP, 3.4 oz/A	0.04	0.22	0.00 C	0.00	2.5
Diamond 7.5WG, 39.75 oz/A	0.02	0.06	0.02 BC	0.00	2.0
Danitol 2.4EC, 21 fl oz/A	0.00	0.00	0.00 C	0.00	2.0
Untreated check	0.00	0.00	0.11 A	0.05	2.8
P value (trtmt effect)	*0.67*	*0.63*	*0.046*	*0.61*	*0.07*

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