Codling Moth and Mite Management in Ohio Apple Orchards

Report to the Ohio Fruit Growers Society, 29 December 2003

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Background

Codling moth is the key pest of apples. If uncontrolled, codling moth larvae bore into and ruin the fruit. Apple growers have been fortunate that codling moth has been easily controlled by reasonably priced organophosphate insecticides for the past few decades. In 2002, codling moth damage was extremely high (10 to 60%) in some orchards in Ohio and other midwestern and northeastern States, 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. Non-organophosphate insecticides are becoming available but they are generally less reliable and more expensive than organophosphates. 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 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.

A separate but related problem is European red mite, an important leaf-feeding pest. Mites can be fully or partially controlled by naturally occurring predatory mites if the predators are not killed by harsh pesticides. A survey of predators in Ohio orchards in 1992 showed that most predators were the white species *Neoseiulus fallacis*, in the Phytoseiid family. During the past 5 years, we have documented a shift in predator species in several orchards, with an increase in occurrence of the yellow species *Zetzellia mali*, in the Stigmaeid family. This is likely due to a decrease in use of Omite and Thiodan. Information is needed on whether this trend is common in Ohio orchards.

The objectives of this project were to determine which insecticides are most effective for codling moth control in midwestern apple orchards, and to survey the extent that phytoseiid and stigmaeid predatory mites are found in representative commercial orchards.

Methods

Field trials on codling moth control were conducted at three sites where control by Imidan had been poor the previous year. Treatments targeted first generation codling moth larvae and were applied three times, first at approximately 150 degree-days (base 50ºF) after sustained flight of codling moth, then at 14-day intervals. Damage was evaluated on fruit in the center of each plot non-destructively in July to evaluate first generation damage, and destructively at harvest in September or October to evaluate second generation damage. Data from replicated trials were analyzed by analysis of variance with means separated by LSD tests.

At all sites, pheromone traps were used to monitor adult populations of codling moth as well as lesser appleworm and oriental fruit moth. Pherocon-VI sticky traps with long-life lures made by Trécé were used for codling moth. Multi-Pher traps were used for lesser appleworm and oriental fruit moth. 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.

A field trial was done in small plots at OSU's Waterman Laboratory in Franklin County, central Ohio, with nine treatments each with four replicates in a randomized complete block design with three adjacent Melrose trees per plot. Treatments included the registered insecticides Assail (acetamiprid), Avaunt (indoxacarb), Danitol (fenpropathrin), Esteem (pyriproxyfen), Imidan (phosmet), and Intrepid (methoxyfenozide), as well as the unregistered insecticides Calypso (thiacloprid) and Diamond (novaluron), and an untreated check. Insecticide treatments were applied by a hand-gun sprayer on 8 May at 113 degree-days 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. After the three experimental sprays, a uniform program of Imidan was used five times on all plots except the untreated check.

Field trials on codling moth control also were conducted in large plots at two commercial orchards in Sandusky County in northwestern Ohio and in Wayne County in northeastern Ohio. Five insecticides compared were Assail, Avaunt, Danitol, Imidan, and Intrepid. Treatments were applied by the growers using airblast sprayers.

The trial in Sandusky County had five treatments each with three replicates in a randomized complete block design with each plot five rows wide and about 1.2 acres in area; the block had eight cultivars with Fuji and Gala dominant. Insecticides were applied in 50 gallons of water per acre. Insecticide

treatments were applied on 13 June at 265 degree-days, on 30 June, and 14 July. After the three experimental sprays, two insecticide sprays were applied on all plots; one with Imidan plus Lannate and one with Imidan alone.

The orchard in Wayne County used the same five experimental products but in an unreplicated observation trial with one product used in each of five different 3-acre blocks, all with mixed cultivars. Insecticides were applied in 100 gal/A. Insecticide treatments were applied on 15 May at 157 degree-days, on 30 May, and 16 June. After the three experimental sprays, two insecticide sprays were applied; one with Lannate alone on all plots and one with Imidan alone on all plots except the Intrepid block which was treated with Imidan plus Lannate.

Mites were surveyed in 15 commercial orchards in 11 counties between mid-July and mid-August. Red Delicious or other mite-susceptible cultivars were sampled. At each site, six samples were taken, with one tree per sample and 25 leaves per tree. Leaves were brushed with a mite-brushing machine, and mites were counted in subsamples to determine the average number of European red mite and predatory mites per leaf. Predators were saved for later species identification.

Results

Pheromone traps at the Franklin County site 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. At the Wayne County site, codling moth began sustained flight on 2 May, the first flight peaked on 18 June with a mean of 72.0 moths per trap per week, and the second flight peaked on 6 August with a mean of 31.3 moths per trap per week. At the Sandusky County site, codling moth began sustained flight on 30 May, the first flight peaked on 18 June with a mean of 13.0 moths per trap per week, and the second flight peaked on 20 August with a mean of 14.7 moths per trap per week.

In the small-plot trial in Franklin County, the untreated treatment showed that pressure from codling moth was intense; 16% of fruit were damaged by early July and 49% by September (Table 1). All eight insecticide treatments worked equally well and were significantly better than the untreated check when evaluated in early July, but significant treatment differences were detected at harvest in September. Codling moth control was best by Diamond and worst by Esteem.

In the large plot replicated trial in Sandusky County, all products provided excellent control of codling moth (<0.3% damage) as measured both in July and in October (Table 2). In the large plot unreplicated trial in Wayne County, four of the five insecticides provided excellent control (<1.5%) as measured both in July and in October, but the block where Intrepid was used showed higher damage (7.4% in July; 9.7% in October) than the other treatments (Table 3).

The mite survey showed that stigmaeid predators were present in nine of the fifteen orchards (Table 4); the ratio of predators to prey was high at three sites and low at six sites, if prey are assumed to be European red mite eggs and a high ratio is at least one to ten. Phytoseiid predators were present in thirteen of the fifteen orchards; the ratio of predators to prey was high at eight sites and low at five sites, if prey are assumed to be European red mite motiles and a high ratio is at least one to ten. Sites 8, 14, and 15 were particularly interesting in having more predator mites than prey mites and in having both types of predators. Although a formal survey of pesticide use in these orchards has not yet been made, discussions with orchard managers indicate that absence of stigmaeid predatory mites is associated with use of pyridaben (Pyramite).

Discussion

Codling moth control by Imidan at all three sites was better than expected in 2003, possibly due to increased spray water volume at the two commercial sites, or due to better (earlier) timing than in the previous year. Weather in 2003 was cooler and rainier than usual, particularly in northern Ohio. 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 at the Franklin County and Wayne County sites, and moderate at the Sandusky County site.

The mite survey showed that stigmaeid predatory mites have become more common in Ohio orchards since the 1992 survey. This data needs to be followed up by extending to growers our existing information on toxicity of specific pesticides to stigmaeid mites.

In conclusion, this project showed that codling moth control by organophoshates can be excellent even at sites where they had not performed well previously. The increased spray water volume used at both commercial sites was one factor that probably improved insecticide efficacy. The results also show that most of the newer non-organophosphate insecticides provide excellent control. The inconsistent performance of Intrepid needs to be explored in further trials. 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. Codling moth damage to apple fruit, Franklin County, Ohio, mean[a] of four replicates.

Treatment, 5/8–6/5	*Treatment, 6/20–8/20*	*Damage on 7/3/03 (100 fruit per plot)*	*Damage on 9/18/03 (100 fruit per plot)*
Untreated	Untreated	16.5% A	49.0% A
Esteem 35WP, 5 oz/A	Imidan 70WP, 3 lb/A	2.2% B	25.3% B
Danitol 2.4EC, 21 fl oz/A	Imidan 70WP, 3 lb/A	0.2% B	17.0% BC
Imidan 70WP, 4 lb/A	Imidan 70WP, 3 lb/A	1.0% B	14.2% BC
Calypso 4F, 6 fl oz/A	Imidan 70WP, 3 lb/A	1.5% B	11.2% CD
Avaunt 30 WDG, 6 oz/A	Imidan 70WP, 3 lb/A	0.8% B	10.8% CD
Intrepid 2SC, 16 fl oz/A	Imidan 70WP, 3 lb/A	1.8% B	7.8% CD
Assail 70WP, 3.4 oz/A	Imidan 70WP, 3 lb/A	2.0% B	6.5% CD
Diamond 7.5WG, 39.75 oz/A	Imidan 70WP, 3 lb/A	1.0% B	5.0% D
P value (treatment effect)		*0.0001 (significant)*	*0.0001 (significant)*

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

Table 2. Codling moth damage to apple fruit, Sandusky County, Ohio, 2003, mean of three replicates.

Treatment, 6/13 – 7/14	*Treatment, 7/31 & 8/18*	*Damage on 30 July (500 fruit per plot)*	*Damage on 8 October (200 to 500 fruit per plot; mean 466)*
Assail 70WP, 3.4 oz/A	Imidan+Lannate; Imidan	0.13%	0.26%
Avaunt 30WG, 6 oz/A	Imidan+Lannate; Imidan	0.07%	0.15%
Danitol 2.4EC, 21 fl oz/A	Imidan+Lannate; Imidan	0.07%	0.26%
Intrepid 2F, 16 fl oz/A	Imidan+Lannate; Imidan	0.07%	0.13%
Imidan 70WP, 4 lb/A	Imidan+Lannate; Imidan	0.27%	0.20%
P value (treatment effect)		*0.47 (not significant)*	*0.91 (not significant)*

Table 3. Codling moth damage to apple fruit in unreplicated plots, Wayne County, Ohio, 2003.

Treatment	*Treatment, 7/13 & 8/2*	*Damage on 7 July (500 fruit per treatment)*	*Damage on 4 October (1,000 fruit per treatment)*
Assail 70WP, 3.4 oz/A	Lannate; Imidan	0.6%	0.4%
Avaunt 30WG, 6 oz/A	Lannate; Imidan	1.4%	NA [a]
Danitol 2.4EC, 21 fl oz/A	Lannate; Imidan	0.0%	0.1%
Intrepid 2F, 16 fl oz/A	Lannate; Imidan+Lannate	7.4%	9.7%
Imidan 70WP, 4 lb/A	Lannate; Imidan	0.0%	0.0%

[a] All cultivars in the Avaunt block had been harvested before 4 October.

Table 4. Density of European red mite (ERM) and predatory mites in representative Ohio apple orchards, 2003.

Site number and countylocation (and orchard code)	*Date*	*Cultivar*	*Mean number per leaf*				*Apple rust mite rating (0 to 3)*
			ERM motile	*ERM eggs*	*Stigmaeid (yellow) predators*	*Phytoseiid (white) predators*	
1 Licking (LY)*	7/9/03	Fuji	4.2	39.6	0.19	3.47	1.0
2 Columbiana (PV)*	7/16/03	Delicious	51.8	146.1	0.016	0.699	3.0
3 Columbiana (MR)	7/16/03	Delicious	60.6	216.6	0.136	0.431	2.0
4 Ottawa (MO)*	7/17/03	Delicious	12.9	61.9	0	1.802	0.2
5 Sandusky (ES)*	7/17/03	Fuji, Gala, Jonagold	1.1	1.8	0	0	1.2

6 Knox (GH)*	8/11/03	Delicious	1.6	10.5	0	1.48	2.3
7 Wayne (ML)*	8/11/03	Delicious	3.5	9.0	0	0.027	2.0
8 Holmes (KL)	8/11/03	mixed	0.03	0.1	0.053	0.453	1.0
9 Holmes (MI)	8/11/03	Delicious	3.1	4.4	0.096	0.256	2.7
10 Ross (HI)	8/13/03	Delicious	0.2	0.4	0	0.2	0.5
11 Hocking (LV)	8/13/03	Delicious	0.3	0.5	0	0	1.2
12 Lorain (MD)	8/14/03	Delicious	1.1	3.0	0.133	1.013	2.3
13 Lorain (LE)	8/14/03	Delicious	63.9	164.5	0.027	0.187	2.2
14 Lorain (DO)	8/14/03	Delicious	0.03	0.1	1.984	0.06	0.4
15 Erie (PH)	8/14/03	Delicious	0.1	1.3	1.312	0.268	0.0

* Sites marked were sampled for mites at one or more additional times during summer 2003.