Apple insect management by insecticides in Ohio, 2019

Final report, 12/12/2019 (with correction 2/6/2020)

Celeste Welty, Associate Professor of Entomology, The Ohio State University
Rothenbuhler Laboratory, 2501 Carmack Rd., Columbus OH 43210-1065;
e-mail: welty.1@osu.edu; phone: 614-292-2803; fax: 614-292-9783

Objective: A field trial was conducted for continued evaluation of insecticide options for control of apple insect pests, with emphasis on control of the key internal Lepidoptera pests, codling moth and Oriental fruit moth, as well as an emerging new pest, the brown marmorated stink bug. Efficacy information is needed for the unregistered products Bifenture and Enkounter, in combination with several registered products: Lambda-Cy, Rimon, Avaunt, Altacor, Delegate, and Imidan, compared with programs that include Closer, Lorsban, Assail, and Belay. Enkounter is a pre-mix of methoxyfenozide (TurnStyle) and acetamiprid (Assail) that has potential for control of internal Lepidoptera. In addition, two experimental fungicide programs were compared with a standard fungicide program.

Methods:

The trial was conducted in a 2-acre block of 17-year old apple trees at Ohio State University's Waterman Agricultural and Natural Resources Laboratory in Columbus, Franklin County. Plots were set up in a randomized complete block design with six treatments and four replicates. There were five adjacent 'Scarlet Spur Red Delicious' trees per plot. Insecticides and fungicides were applied in a volume of 75 gallons of water per acre by an AgTech 4002 airblast sprayer, operated at pressure of 20 psi, with TeeJet 6510 and 6520 nozzle tips.

Insecticides included were lambda-cyhalothrin (Lambda-Cy), chlorpyrifos (Lorsban Advanced), indoxacarb (Avaunt), novaluron (Rimon), methoxyfenozide plus acetamiprid (Enkounter), chlorantraniliprole (Altacor), spinetoram (Delegate), phosmet (Imidan), bifenthrin (Bifenture), sulfoxaflor (Closer), acetamiprid (Assail), and clothianidin (Belay). The sequence and rates of products in each treatment are shown in Table 1 for insecticides and in Table 2 for fungicides.

Table 1. Sequence and rates of insecticide products applied in apple pesticide trial, Columbus, Ohio, 2019.

Treatment	Green tip (4/3-4/4)	Pink bud (4/18)	Petal-fall (5/6)	Late petal-fall (5/16)	1st cover (5/21-5/22)	2nd cover (6/6)	3rd cover (6/21)	4th cover (7/3)	5th cover (7/19)	6th cover (8/1) & 7th cover (8/15)
1 UPL-1	-	Lambda-Cy 1EC: 2.56 fl oz/A	-	Rimon 0.83 EC: 32 fl oz/A	Avaunt eVo EW: 6 oz/A	Delegate 25WG: 6 oz/A	Altacor 35WG: 3 oz/A	Imidan 70WP: 3 lb/A	Enkounter 40 SG: 1 lb/A + Bifenture 2EC: 12.8 fl oz/A	Enkounter 40 SG: 1 lb/A
2 UPL-2	Lambda-Cy 1EC: 2.56 fl oz/A		Avaunt eVo EW: 6 oz/A	-	Enkounter 40 SG: 1 lb/A	Enkounter 40 SG: 1 lb/A	Enkounter 40 SG: 1 lb/A	Imidan 70WP: 3 lb/A	Altacor 35W: 3 oz/A + Bifenture 2EC: 12.8 fl oz/A	Altacor 35W: 3 oz/A
3 Corteva-1	Lorsban Advanced: 1 qt/A + oil 2%		Avaunt 30WDG: 6 oz/A	-	Altacor 35WG: 3 oz/A\	Altacor 35WG: 3 oz/A	Altacor 35WG: 3 oz/A	Imidan 70WP: 3 lb/A	Delegate 25WG: 6 oz/A	Delegate 25WG: 6 oz/A
4 Corteva-2	Lorsban Advanced: 1 qt/A + oil 2%		Avaunt 30WDG: 6 oz/A	-	Altacor 35WG: 3 oz/A\	Altacor 35WG: 3 oz/A	Altacor 35WG: 3 oz/A	Imidan 70WP: 3 lb/A	Delegate 25WG: 6 oz/A + Closer 2SC: 5.75 oz/A	Delegate 25WG: 6 oz/A + Closer 2SC: 5.75 oz/A
5 Standard	Lorsban Advanced: 1 qt/A + oil 2%	-	Avaunt 30WDG: 6 oz/A	-	Altacor 35WG: 3 oz/A	Altacor 35WG: 3 oz/A	Altacor 35WG: 3 oz/A	Imidan 70WP: 3 lb/A	Assail 30SG: 6 oz/A + oil: 0.5% + Belay 2.13SC: 6 fl oz/A	Assail 30SG: 6 oz/A + oil: 0.5%
6 Un-treated	-	-	-	-	-		-	-	-	-

Table 2. Sequence and rates of fungicide products applied in apple pesticide trial, Columbus, Ohio, 2019.

Treatment	Primary scab					Secondary scab	
	Green tip (4/3-4/4)	Tight cluster (4/11)	Bloom (4/22)	Petal-fall (5/6)	1st cover (5/21-5/22)	2nd cover (6/6) & 3rd cover (6/21)	4C (7/3), 5C (7/19), 6C (8/1), & 7C (8/15)
1: UPL-1	Procure 480 SC 16 fl oz/A	Manzate Pro-Stick 3 lbs/A + Captan 80WDG 5 lb/A	Manzate Pro-Stik 3 lbs/A + Captan 80WDG 5 lb/A	Manzate Pro-Stick 3 lbs/A	Procure 480 SC 16 fl oz/A + Captan 80WDG 5 lb/A	Captan 80WDG 2.5 lb/A + Fontelis 16 fl oz/A	Captan 80WDG 2.5 lb/A
2: UPL-2	Trionic 4SC 16 fl oz/A	Manzate Pro-Stik 3 lbs/A + Captan 80WDG 5 lb/A	Manzate Pro-Stik 3 lbs/A + Captan 80WDG 5 lb/A	Manzate Pro-Stick 3 lbs/A	Trionic 4SC 16 fl oz/A + Manzate Pro-Stick 3 lbs/A	Captan 80WDG 2.5 lb/A + Fontelis 16 fl oz/A	Captan 80WDG 2.5 lb/A
3, 4, 5, 6: Corteva-1, Corteva-2, Standard, Untreated	Manzate Pro-Stick 6 lbs	Captan 80WDG 5 lb/A	Captan 80WDG 5 lb/A	Captan 80WDG 5 lb/A	Captan 80WDG 5 lb/A	Captan 80WDG 2.5 lb/A + Fontelis 16 fl oz/A	Captan 80WDG 2.5 lb/A

Target timing of the first cover spray was based on observations of codling moth activity in pheromone traps, with Rimon applied at 75-100 degree-days after a trap-based biofix, and Avaunt, Enkounter, and Altacor applied at 150-250 degree-days after biofix. Populations of codling moth (CM), oriental fruit moth (OFM), and lesser appleworm (LAW) were monitored by pheromone traps that were checked three times per week. There were two traps each for CM and OFM, and one trap for LAW. There was a third trap for CM in another apple block nearby and a third trap for OFM in a small peach block nearby but data from these are not included here because moth catches were consistently lower than in the block where the experimental plots and other traps were located. Trends in seasonal abundance of brown marmorated stink bug were determined by pheromone traps: three clear sticky-panel traps on 5-foot wood posts, baited with dual Trécé lures, were placed along the west edge of the orchard in mid-April, and checked once per week until late October; another set of three traps was placed along a natural treeline that was 1.04 km north of the orchard.

Treatments for pre-bloom control of San Jose scale and rosy apple aphid were applied at the green-tip bud stage on 4/03-4/04 or at the pink bud stage on 4/18. Treatments for post-bloom control of plum curculio and leafrollers were applied at the petal-fall stage on 5/06. For fruit thinning, MaxCel at 75 ppm in 75 gal water per acre was applied when king fruit were about 12 mm diameter, on 5/16. Thinner was applied on all trees, including those in untreated check plots.

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 5/15 and in three trees per plot on 6/03 and 7/02. Rosy apple aphid was evaluated by counting the number of infested clusters in middle zone of the canopy in a 1-minute search in one tree per plot on 5/15 and in three trees per plot on 6/03. 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 5/15, 6/03, 6/19, and 7/02; the number of potato leafhopper and predatory arthropods on these leaves was also recorded.

Mite populations were sampled on 6/05 to determine whether or not a miticide was needed. A sample of 25 randomly selected leaves was taken from one tree at the center of each plot. 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 (<2.5 mites per leaf), moderate (2.5 to 25 mites per leaf), or high (>25 mites per leaf) for each sample.

Insect injury on fruit was evaluated on 100 randomly selected fruit from the center of each plot, non-destructively on 7/09-7/10, which was between the first and second flights of CM and between the second and third flights of OFM, and destructively at harvest on 8/30-9/03.

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:

All three species of internal Lepidoptera were abundant in pheromone traps as shown in the graph with a single Y-axis (Fig. 1) and two Y-axes (Fig. 2). This is the third consecutive year that OFM has been present at high density in this orchard. The trap-based biofix dates were 4/17 for OFM and 5/09 for CM. Degree-day accumulations relative to biofix dates are shown in Table 3 for CM (base 50° F with upper threshold of 88°F) and OFM (base 45° F with upper threshold of 90°F). The population of brown marmorated stink bug (BMSB), as detected by pheromone traps, was found at lower density at the edge of the apple orchard (Fig. 3A) than in a natural treeline that was about 1.04 km north of the orchard. Adult BMSB were consistently caught in the orchard starting in early August, and BMSB nymphs were first detected in the orchard in early September, whereas in the natural treeline, adult BMSB were consistently caught starting in late June, and BMSB nymphs were first detected in early July. The cover sprays that likely had greatest impact on BMSB were the sixth and seventh covers.

Fruit injury from insect pests as of mid-summer is shown in Table 4. Injury by internal Lepidoptera was significantly higher in the untreated plots (38.6% of fruit injured) than in any of the treated plots (2.5-6.9% of fruit injured). Injury by both San Jose scale and plum curculio was highest in the untreated plots and in the Corteva-2 treatment, but significantly lower in the UPL-2 treatment (Table 4). Injuries by stink bugs and tarnished plant bug were also found but did not differ significantly among treatments (Table 4). The percentage of fruit that was clean of all insect injuries was significantly higher in all insecticide treatments than in untreated plots, and the UPL-2 treatment had significantly more clean fruit than the Corteva-2 treatment, while the other three insecticide treatments were intermediate (Table 4).

Fruit injury from insect pests as of harvest time is shown in Table 5. An extremely high level of damage by internal Lepidoptera was found in untreated plots (76.7% of fruit injured) but all insecticide treatments had significantly less internal Lepidoptera injury (3.4 to 11.9% of fruit injured), and the UPL-2 treatment had significantly fewer internal Lepidoptera-injured fruit than the Corteva-2 treatment (Table 5). Injury by San Jose scale was found in all treatments, but was significantly less in the UPL-2 treatment than in four of the five other treatments, with the standard treatment at an intermediate level (Table 5). Injuries by plum curculio, stink bugs, tarnished plant bug, and late leafrollers were also found but did not show significant treatment effects (Table 5).

Rosy apple aphid was present but at low density, with no significant differences among treatments on 5/15 or 6/03 (Table 6). Woolly apple aphid also was present but at low incidence, with no significant differences among treatments on 5/15, 6/03, or 7/02 (Table 6). Green apple aphid was present but at low density, with no significant differences among treatments on 5/15, 6/03, or 7/02, but with significantly higher incidence on 6/19 in the UPL-1 treatment than in any of the other treatments (Table 7), .

Potato leafhopper was not detected on 5/15 but was detected in all treatments on 6/3, with significant treatment effects shown on 6/3, 6/19, and 7/2 (Table 7). The UPL-1 and UPL-2 treatments had significantly fewer leafhoppers on 6/19 than the other four treatments. By 7/02, most leafhopper nymphs had molted to adults and left the orchard.

Predatory arthropods found on terminal shoots associated with potato leafhopper and green apple aphid included *Orius* adults, spiders, lacewing eggs, lady beetle adults, and aphid midge larvae (*Aphidoletes aphidimyza*), all found at low density, without significant treatment differences (Table 8).

European red mite was not detected in any treatment on 6/05, which contributed to the decision that miticide treatments were not needed. Apple rust mite ratings were significantly higher in UPL-2 than in UPL-1 or the standard treatment, with the other treatments at intermediate levels (Table 9). Both stigmaeid and phytoseiid predatory mites were detected but with no treatment effect (Table 9).

Conclusions: The two Corteva treatments, which differed from each other only by inclusion or no inclusion of Closer in three cover sprays in late summer, provided similar results in their effect on insect injury by harvest; both provided good control of internal Lepidoptera but poor control of San Jose scale. The two UPL treatments both included Enkounter, a pre-mix of methoxyfenozide plus acetamiprid; they differed from each other in several ways but primarily with Enkounter used for second generation CM control in UPL-1 and Enkounter used for first generation CM control in UPL-2. Results showed better control of internal Lepidoptera and San Jose scale by the UPL-2 program than by the UPL-1 program. All insecticide programs would likely have provided better control of internal Lepidoptera if the timing had been based on activity of OFM rather than CM due to the much greater abundance of OFM in the orchard in 2019.

Acknowledgements: Treatment applications and orchard maintenance by Glenn Mills and Kevin Schrock were greatly appreciated, as was technical assistance by Brittany Heigley, Vashti Tatman, and Kristina Fox Vik. Funding and products were supplied by United Phosphorus Inc. and Corteva Agriscience. Additional products were graciously provided by representatives of FMC Corp., Gowan Company, and Valent U.S.A. LLC.

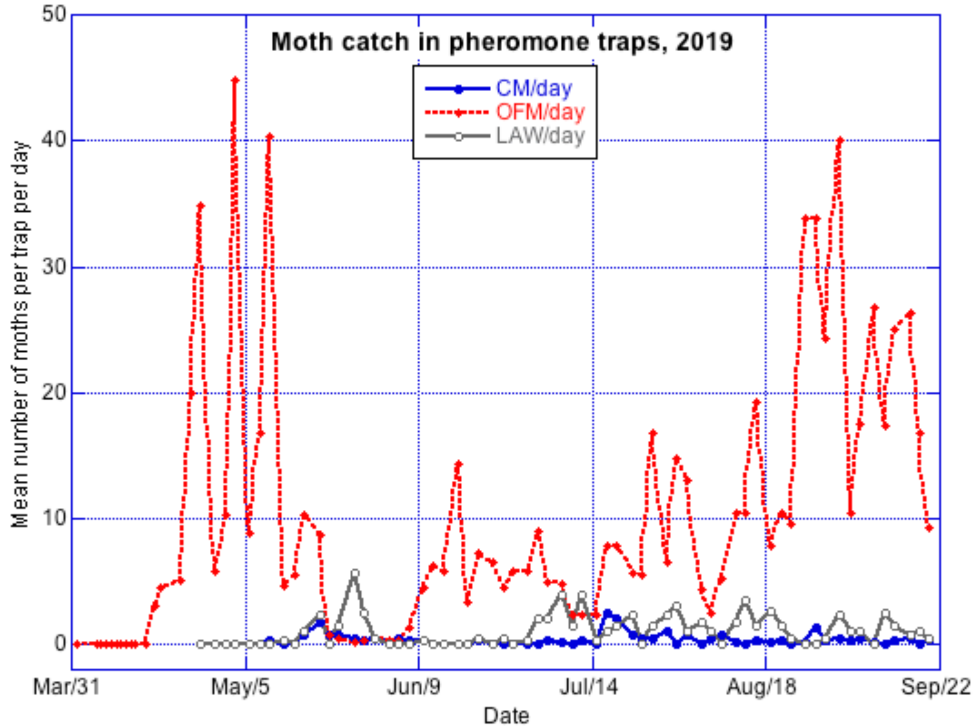

Fig.1. Seasonal population trends in codling moth (CM), Oriental fruit moth (OFM), and lesser appleworm (LAW) in 2019 as measured by pheromone traps at OSU's Waterman Lab, Columbus, Ohio; shown with all three species on same scale on y-axis.

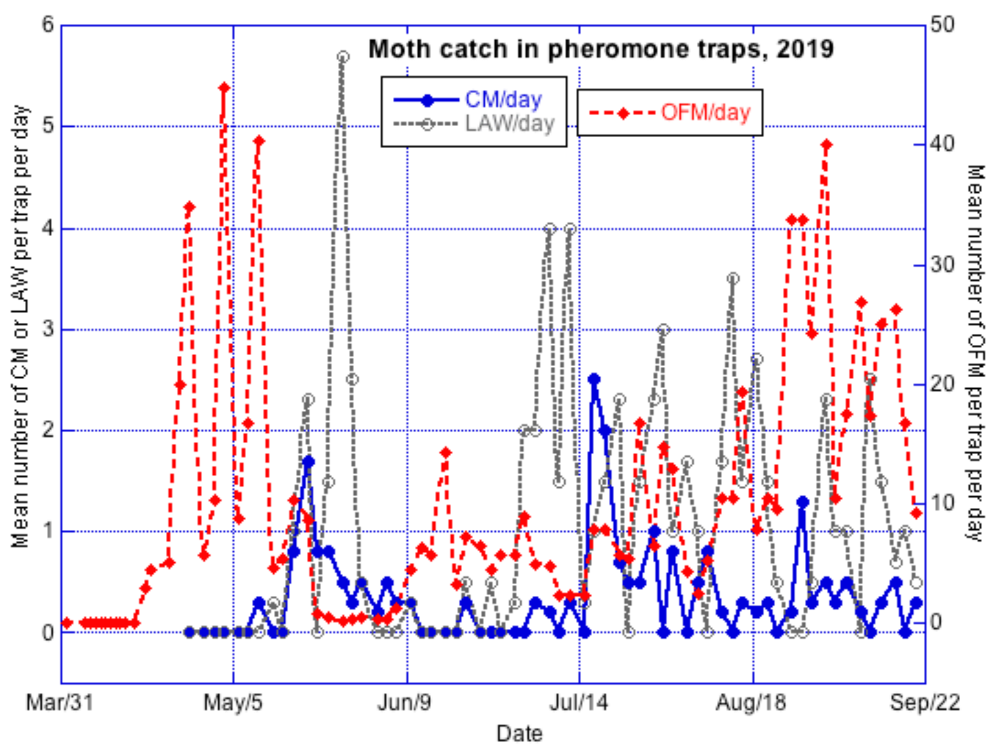

Fig. 2. Seasonal population trends in codling moth (CM), Oriental fruit moth (OFM), and lesser appleworm (LAW) in 2019 as measured by pheromone traps at OSU's Waterman Lab, Columbus, Ohio; shown with CM and LAW on larger scale on y-axis (labeled on left), and OFM on smaller scale on y-axis (labeled on right).

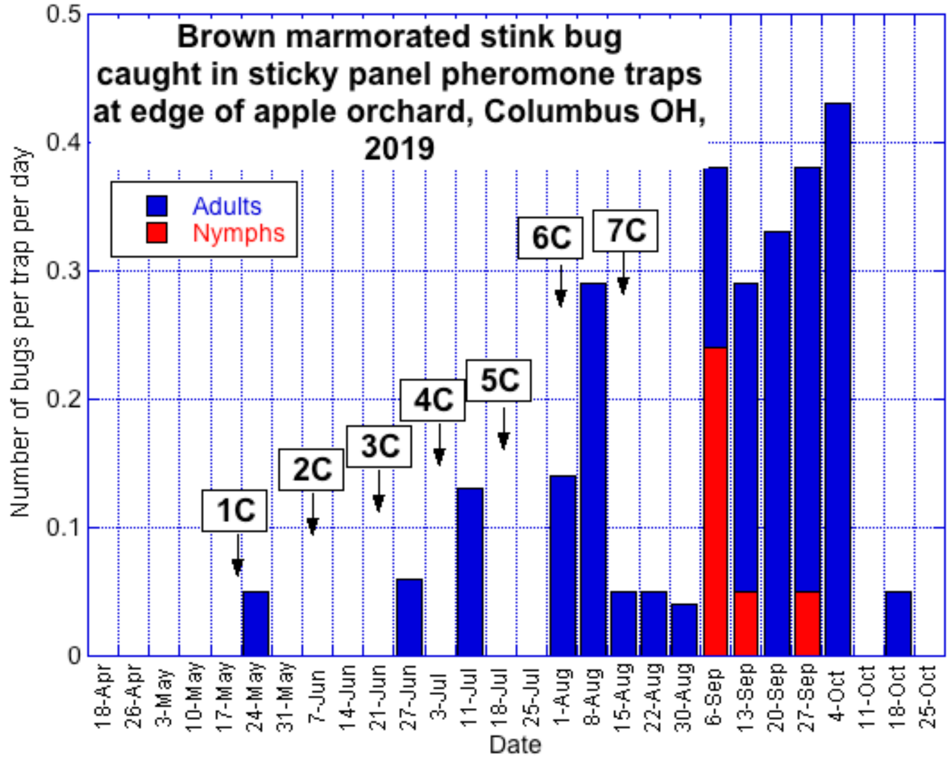

Fig. 3A. Seasonal population trends in brown marmorated stink bug adults and nymphs in 2019 as measured by pheromone traps at the western edge of the apple orchard at OSU's Waterman Lab, Columbus, Ohio. Dates of insecticide cover sprays are indicated by arrows; 1C = first cover, 2C = second cover, etc.

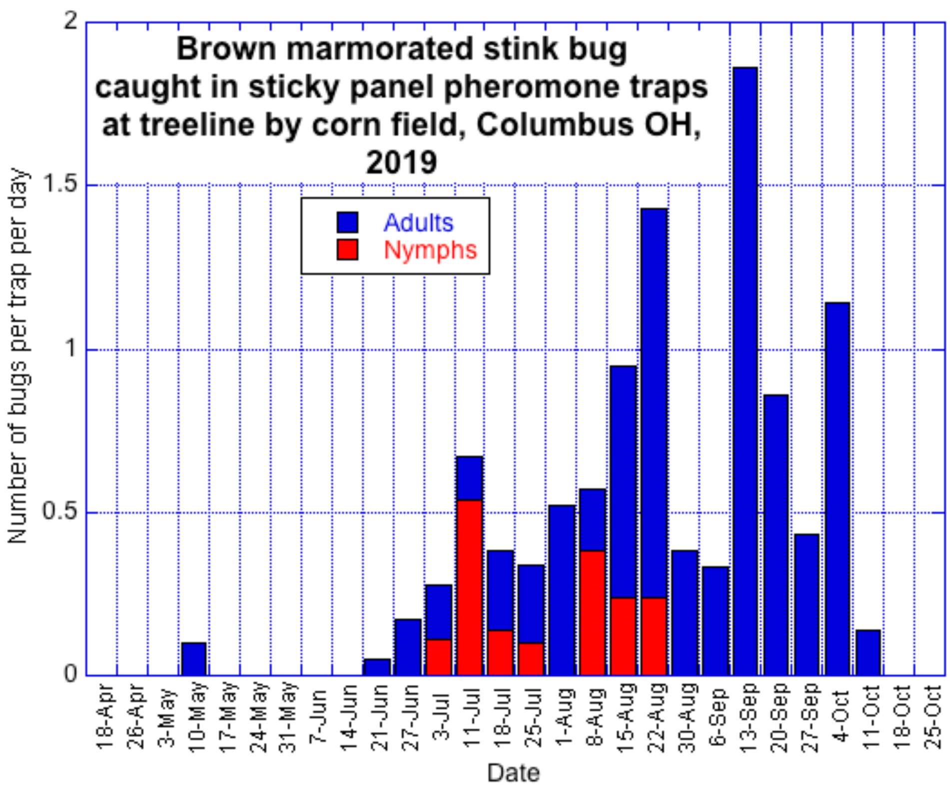

Fig. 3B. Seasonal population trends in brown marmorated stink bug adults and nymphs in 2019 as measured by pheromone traps along a natural treeline at the north end of OSU's Waterman Lab, Columbus, Ohio.

Table 3. Degree-day accumulations relative to spray dates for apple trial, Columbus, Ohio, 2019.

Spray	*Date*	*Degree-days after codling moth biofix on 5/09*	*Degree-days after OFM biofix on 4/17*
Pink bud	4/18	-	44
Petal-fall	5/06	-	270 (ideal timing: 150-170 for 1st gen.)
Late petalfall	5/16	75 (ideal timing: 75-100 for 1st generation)	415
1st cover	5/21	161 (ideal timing: 150-250 for 1st generation)	524
2nd cover	6/06	500	943 (ideal: 1125-1150 for 2nd gen.)
3rd cover	6/21	786	1303
4th cover	7/03	1102	1684
5th cover	7/19	1559 (59 after re-biofix on 7/17)	2230 (ideal 2250-2280 for 3rd gen.)
6th cover	8/01	1882 (382 after re-biofix)	2620
7th cover	8/15	2231 (731 after re-biofix)	3041 (ideal 3375-3430 for 4th gen.)

Table 4. Insect injury[a] to 'Delicious' apple fruit after treatment by six insecticide programs, evaluated non-destructively on 9-10 July 2019; mean of four blocked replicates at OSU's Waterman Lab, Columbus, Ohio.

Treatment (codling moth 1st generation)	% Internal Lepidoptera			% San Jose scale[b]	% Plum curculio oviposition[b]	% Stink bug	% Tarnished plant bug	% Clean of insect damage[b]
	Entry[b]	Sting[b]	Total[b]					
UPL-2 (Enkounter)	1.8 B	1.0 BC	2.8 B	0.0 C	0.5 C	0.3	1.8	94.7 A
Corteva-1 (Altacor)	2.0 B	0.5 C	2.5 B	1.8 BC	1.3 BC	0.0	2.8	91.6 AB
UPL-1 (Rimon/Avaunt/Delegate/Altacor)	3.2 B	0.2 C	3.4 B	2.9 BC	2.4 BC	0.9	0.2	90.0 AB
Standard (Altacor)	3.0 B	1.0 BC	4.0 B	5.0 B	2.0 BC	1.0	2.2	86.3 AB
Corteva-2 (Altacor)	4.2 B	2.7 B	6.9 B	4.9 AB	3.7 AB	0.2	2.0	82.6 B
untreated	30.0 A	8.6 A	38.6 A	10.5 A	7.5 A	0.5	3.0	46.0 C
P (treatment effect)	*0.0001*	*0.0003*	*<0.0001*	*0.0020*	*0.0163*	*0.75*	*0.20*	*<0.0001*

[a] Values shown are actual percentages, but ANOVA based on transformed values.

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

Table 5. Insect injury[a] to 'Delicious' apple fruit after treatment by six insecticide programs, evaluated destructively at harvest on 30 August - 3 September 2019; mean of four blocked replicates at OSU's Waterman Lab, Columbus, Ohio.

Treatment (codling moth 1st generation; 2nd generation)	% Internal Lepidoptera			% San Jose scale[b]	% Plum curculio		% Stink bug	% Tarnish-ed plant bug	% Leaf-roller (late)	% Clean of insect damage[b]
	Entry[b]	Sting[b]	Total[b]		Ovipo -sition	Late Feed-ing				
UPL-2 (Enkounter; Altacor+Bifenture/ Altacor)	1.0 B	2.4 C	3.4 C	8.5 B	0.0	0.0	1.0	1.2	0.2	86.1 A
Standard (Altacor; Assail)	2.2 B	8.1 BC	10.3 BC	20.4 AB	7.9	0.5	3.8	2.7	0.0	60.2 B
UPL-1 (Rimon/Avaunt/Delegate/Altacor; Enkounter+Bifenture; Enkounter)	4.4 B	5.9 BC	10.3 BC	30.7 A	2.6	0.0	3.7	0.7	0.5	55.7 B
Corteva-2 (Altacor; Delegate+Closer)	2.7 B	9.2 B	11.9 B	30.5 A	6.2	0.5	1.0	3.0	0.0	54.9 B
Corteva-1 (Altacor; Delegate)	3.1 B	8.5 BC	11.6 BC	33.9 A	1.9	1.0	2.5	2.5	0.2	52.8 B
untreated	54.4 A	22.3 A	76.7 A	34.4 A	2.5	1.2	5.5	1.7	0.0	8.5 C
P (treatment effect)	<0.0001	*0.0015*	<0.0001	*0.0198*	*0.20*	*0.16*	*0.28*	*0.08*	*0.36*	<0.0001

[a] Values shown are actual percentages, but ANOVA based on transformed values.

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

Table 6. Woolly apple aphid and rosy apple aphid infestation on 'Delicious' apple trees, Columbus, Ohio, 2019, as detected by scouting in early summer.

Treatment	Mean number of clusters infested with **rosy apple aphid** per tree on two sampling dates		Presence or absence of **woolly apple aphid** (0 = absent; 1 = present) [a] on three sampling dates		
	5/15 (1 tree/plot)	6/03 (3 trees per plot)	5/15 (1 tree/plot)	6/03 (3 trees per plot)	7/02 (3 trees per plot)
UPL-2	0	0	0	0.2	0.5
Corteva-1	0	0.1	0	0.4	0.3
Corteva-2	0	0.2	0.2	0.5	0.5
Standard	1.2	0.7	0.2	0.5	0.4
UPL-1	0	0.1	0	0.6	0.8
Untreated	0.8	1.0	0.2	0.7	0.4
Probability for treatment effect	*P = 0.45*	*P = 0.53*	*P = 0.75*	*P = 0.60*	*P = 0.54*

[a] Values shown are actual proportions but ANOVA based on transformed values.

Table 7. Potato leafhopper and green apple aphid and on terminal shoots of 'Delicious' apple trees, Columbus, Ohio, 2019, as detected by scouting in early summer.

Treatment	Mean number of **potato leafhopper** per leaf on four sampling dates				Mean percentage[b] of terminal leaves infested by **green apple aphid** on four sampling dates			
	5/15	6/03 [a]	6/19 [a]	7/02 [a]	5/15	6/03	6/19 [a]	7/02
UPL-2	0	0.02 C	0.07 B	0.02 B	0	0.01	0.01 B	0.00
UPL-1	0	0.01 C	0.27 B	0.18 A	0.01	0.01	0.10 A	0.04
Corteva-1	0	0.23 BC	0.80 A	0.05 B	0	0.01	0.00 B	0.00
Untreated	0	0.59 A	0.84 A	0.02 B	0	0.02	0.03 B	0.06
Corteva-2	0	0.42 AB	0.98 A	0.06 B	0	0.02	0.01 B	0.06
Standard	0	0.36 AB	0.98 A	0.07 B	0	0	0.02 B	0.01
Probability for treatment effect	-	*P =0.0041*	*P=0.0006*	*P = 0.036*	*P=0.45*	*P=0.91*	*P=0.0210*	*P=0.54*

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

Table 8. Predators associated with green apple aphid and potato leafhopper on terminal shoots of 'Delicious' apple trees, Columbus, Ohio, 2019, as detected by scouting in early summer.

Treatment	Mean number of predators per leaf on terminal shoots									
	5/15	6/03		6/19			7/02			
	All	Orius (adults)[a]	Spiders	Orius (adults)[a]	Spiders	Lacewing (eggs)	Orius (adults)[a]	Spiders	Lacewing (eggs)	Lady beetle (adults)	predatory midge (larvae)
Corteva-2	0	0	0	0	0.005	0	0.005	0.01	0.01	0.01	0.01
UPL-1	0	0	0.005	0.005	0	0	0.005	0	0	0.005	0.02
UPL-2	0	0.005	0	0	0	0.005	0.005	0.01	0	0	0
Corteva-1	0	0	0	0	0.01	0.005	0.01	0.005	0	0	0
Untreated	0	0	0	0	0	0.01	0	0.005	0.01	0	0
Standard	0	0.005	0.005	0	0	0	0	0	0.005	0	0
Probability for treatment effect	-	*0.45*	*0.45*	*0.45*	*0.57*	*0.45*	*0.59*	*0.67*	*0.39*	*0.45*	*0.45*

Table 9. Density of European red mite (ERM) and associated mites on 'Delicious' apple leaves on 5 June 2019, Columbus, Ohio.

Treatment	Mean number per leaf		Mean rating of apple rust mite density[a, b]	Mean number of predators per leaf	
	ERM motiles	ERM eggs		Stigmaeid motiles[c]	Phytoseiid motiles
UPL-2	0	0	1.25 A	0.06	0.26
Corteva-1	0	0	1.00 AB	0.04	0.20
Untreated	0	0	1.00 AB	0.22	0.12
Corteva-2	0	0	0.75 AB	0.07	0.11
Standard	0	0	0.50 BC	0.06	0.12
UPL-1	0	0	0.00 C	0.16	0.08
Probability for treatment effect	-	-	*P = 0.0339*	*P* = 0.72	*P = 0.37*

[a] Density rating scale: 0 = none; 1 = low (<2.5 per leaf); 2 = moderate (2.5 to 25 per leaf); 3 = high (>25 per leaf).

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

[c] Note on stigmaeid predators: Some of the counts included here were Stigmaeids with the characteristic color and shape; also included were some mites that were the classic shape but paler than the classic bright yellow color. Specimens were saved and identification will be pursued at the Acarology Laboratory later this winter.