**Apple insect management by insecticides in Ohio, 2016**

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## Methods:

The trial was conducted in a 2-acre block of 14-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 were three guard rows between adjacent treatment rows. Insecticides 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.

Table 1. Sequence and rates of products applied in apple insecticide trial, Columbus, Ohio, 2016.

| Trtmt # | Half-inch green (4/1) | Pink bud (4/14) | Petal-fall (4/29) | 1C (5/27; 233 DD after biofix on 5/7) & 3C (6/24) | 2C (6/9) | 4C | 5C (7/21; 266 DD after re-biofix on 7/11) & 6C (8/3) |
|---|---|---|---|---|---|---|---|
| 1 FMC 1 | - | Mustang Max: 4 fl oz/A | Gladiator 0.33EW: 18 fl oz/A + oil 0.5% | Delegate 25WG: 5.2 oz/A | Delegate 25WG: 5.2 oz/A + Beleaf 50 SG 2.8 oz/A | - | Altacor 35WG: 3 oz/A |
| 2 FMC2 | - | Mustang Max: 4 fl oz/A + Beleaf 50 SG 2.8 oz | Gladiator 0.33EW: 18 fl oz/A + NIS 0.25% v/v | Delegate 25WG: 5.2 oz/A | Delegate 25WG: 5.2 oz/A + Beleaf 50 SG 2.8 oz/A | - | Altacor 35WG: 3 oz/A |
| 3 Dow | Lorsban Advanced: 1 qt/A | - | Imidan 70WP: 3 lb/A | Delegate 25WG: 5.2 oz/A | Delegate 25WG: 5.2 oz/A + Closer 1.5 fl oz/A | - | Altacor 35WG: 3 oz/A |
| 4 Dupont | Lorsban Advanced: 1 qt/A | - | Avaunt 30WDG: 6 oz/A | Altacor 35WG: 3 oz/A | Altacor 35WG: 3 oz/A | - | Assail 30SG: 6 oz/A + oil 0.5% |
| 5 UTC | - | - | - | - | | - | - |

## Results and Discussion:

Damage from codling moth was lighter than expected, possibly due to a heavy fruit load that diluted its effect. All insecticide programs resulted in fruit that was significantly less infested by internal Lepidoptera than untreated trees, but there were no significant differences among the insecticide treatments.

Table 2. Insect injury[a] to 'Delicious' apple fruit after treatment by six management programs, evaluated non-destructively on 6-7 July 2016; mean of four blocked replicates at OSU's Waterman Lab, Columbus, Ohio.

| Treatment (prebloom/ petalfall/ codling moth 1st generation) | % Internal Lepidoptera | | | % San Jose Scale | % Plum curculio | % Tar-nished plant bug | % stink bug | % rosy apple aphid | % Clean of insect damage |
|---|---|---|---|---|---|---|---|---|---|
| | Entry[b] | Sting | Total[b] | | | | | | |
| Lorsban/Imidan/Delegate | 0.0 B | 0.2 | 0.2 B | 14.0 | 1.0 | 1.0 | 0.2 | 0.0 | 83.8 |
| Mustang/GladiatorOil/Delegate | 0.0 B | 0.2 | 0.2 B | 22.8 | 0.2 | 1.0 | 0.0 | 0.0 | 75.8 |
| Mustang/GladiatorNIS/Delegate | 0.0 B | 0.5 | 0.5 B | 17.0 | 0.5 | 0.2 | 0.0 | 0.0 | 81.8 |
| Lorsban/Avaunt/Altacor | 0.2 B | 1.8 | 2.0 AB | 10.8 | 1.0 | 2.0 | 0.0 | 0.0 | 83.8 |
| untreated | 3.2 A | 3.5 | 6.8 A | 16.0 | 0.8 | 0.5 | 0.5 | 0.2 | 75.2 |
| *P (treatment effect)* | *P = 0.0002* | *P = 0.0597* | *P = 0.0107* | *P = 0.96* | *P = 0.90* | *P = 0.17* | *P = 0.16* | *P = 0.44* | *P = 0.96* |

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

Table 3. Insect injury[a] to 'Delicious' apple fruit after treatment by six insecticide programs, evaluated destructively at harvest on 17-18 August 2016; mean of four blocked replicates at OSU's Waterman Lab, Columbus, Ohio.

| Treatment (codling moth 1st generation/ 2nd generation) | % Internal Lepidoptera | | | % San Jose scale | % Stink bug | % Plum curculio | | % Tar-nished plant bug | % Leaf-roller (late) | % Apple mag-got | % Apple cur-culio | % Clean of insect damage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Entry[b] | Sting[a] | Total[b] | | | Ovipo-sition | Late feed-ing[b] | | | | | |
| Altacor/Assail (DuPont) | 0.2 B | 1.8 B | 2.0 B | 27.5 | 6.5 | 2.2 | 0.5 B | 0 | 0.0 | 0 | 0.0 | 62.5 |
| Delegate/Altacor (FMC2) | 0.2 B | 1.8 B | 2.0 B | 55.2 | 9.2 | 1.0 | 0.0 B | 0 | 0.0 | 0 | 0.0 | 37.5 |
| Delegate/Altacor (FMC1) | 0.8 B | 1.5 B | 2.2 B | 49.6 | 6.2 | 1.0 | 0.3 B | 0 | 0.0 | 0 | 0.0 | 45.7 |
| Delegate/Altacor (Dow) | 0.5 B | 1.8 B | 2.3 B | 54.2 | 4.5 | 0.5 | 3.5 A | 0.8 | 0.01 | 0.8 | 0.01 | 38.1 |
| untreated | 9.5 A | 10.2 A | 19.7 A | 42.6 | 8.0 | 3.2 | 3.2 A | 0 | 0.0 | 0 | 0.0 | 34.2 |
| *P (treatment effect)* | *0.0018* | *0.0260* | *0.0016* | *0.75* | *0.85* | *0.15* | *0.0032* | *0.44* | *0.44* | *0.44* | *0.44* | *0.55* |

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

Table 4. Rosy apple aphid (RAA) woolly apple aphid (WAA) infestation detected on 'Delicious' apple trees, Columbus, Ohio, 2016, as detected by scouting three trees per plot.

| Treatment (prebloom/ petalfall/ codling moth 1st generation) | Number of clusters infested with **RAA** per tree on four sampling dates | | | | Presence or absence of **WAA** (0 = absent; 1 = present) on four sampling dates | | | |
|---|---|---|---|---|---|---|---|---|
| | 5/11 | 5/25 | 6/8 | 6/23 | 5/11 | 5/25 [a] | 6/8 | 6/23 |
| Lorsban/Avaunt/Altacor (DuPont) | 0.0 | 0.0 | 0.00 | 0.0 | 0.25 | 0.33 B | 0.17 | 0.00 |
| Lorsban/Imidan/Delegate (Dow) | 0.0 | 0.0 | 0.00* | 0.0 | 0.25 | 0.33 B | 0.17* | 0.00 |
| MustangBeleaf/GladiatorNIS/Delegate (FMC2) | 0.0 | 0.0 | 0.08* | 0.0 | 0.33 | 0.75 A | 0.58* | 0.00 |
| Mustang/GladiatorOil/Delegate (FMC1) | 0.0 | 0.0 | 0.08* | 0.0 | 0.50 | 0.92 A | 0.58* | 0.17 |
| untreated | 0.3 | 5.25 | 2.0 | 2.58 | 0.75 | 0.92 A | 0.25 | 0.00 |
| *Probability (treatment effect)* | *0.44* | *0.11* | *0.35* | *0.32* | *0.23* | *0.0125* | *0.26* | *0.44* |

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

* Counts on 6/8 were one day before the second cover spray that included Closer in the Dow treatment and Beleaf in two FMC treatments.

Table 5. Green apple aphid on terminal shoots of 'Delicious' apple trees, Columbus, Ohio, 2016.

| Treatment (prebloom/ petalfall/ codling moth 1st generation) | Percentage[a] of terminal leaves infested on four sampling dates | | | |
|---|---|---|---|---|
| | 5/11 | 5/25 | 6/8[b] | 6/23 |
| untreated | 9.0 | 17.5 | 0.5 C | 2.0 |
| Lorsban/Avaunt/Altacor (DuPont) | 10.5 | 18.0 | 10.0 BC | 4.5 |
| Lorsban/Imidan/Delegate (Dow) | 11.5 | 20.0 | 33.5 AB * | 3.5 |
| Mustang/GladiatorOil/Delegate (FMC1) | 8.0 | 21.5 | 50.5 A* | 1.0 |
| MustangBeleaf/GladiatorNIS/Delegate (FMC2) | 6.0 | 29.0 | 52.0 A * | 4.0 |
| *Probability for treatment effect* | *0.64* | *0.11* | *0.0016* | *0.82* |

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

* Counts on 6/8 were one day before the second cover spray that included Closer in the Dow treatment and Beleaf in two FMC treatments.

Table 6. Predators associated with green apple aphid on 'Delicious' apple trees, Columbus, Ohio, 2016.

| Treatment (prebloom/ petalfall/ codling moth 1st generation) | Number of predators on endmost 5 leaves of terminal shoot | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5/11 | 5/25 | | 6/8 | | | | 6/23 | |
| | Lady beetle (adults) | Lady beetle (adults) | Lace-wing (larvae) | Lady beetle (adults & larvae) | Orius (adults & nymphs) | Lace-wing (larvae) | Orange midge, *Aphidoletes aphidimyza* (larvae) | Lady beetle (adults) | Orius (adults & nymphs) |
| untreated | 0.02 | 0.08 | 0 | 0.02 | 0 | 0 | 0 | 0 | 0.05 |
| Lorsban/Avaunt/Altacor (DuPont) | 0 | 0.05 | 0.02 | 0.08 | 0 | 0.02 | 0 | 0.02 | 0.02 |
| Lorsban/Imidan/Delegate (Dow) | 0 | 0.02 | 0 | 0.20 | 0.05 * | 0 * | 0.30 * | 0 | 0 |
| Mustang/GladiatorOil/Delegate (FMC1) | 0 | 0 | 0 | 0.28 | 0 * | 0 * | 0.25 * | 0 | 0.02 |
| MustangBeleaf/GladiatorNIS/Delegate (FMC2) | 0 | 0.08 | 0 | 0.10 | 0.05 * | 0 * | 0.08 * | 0 | 0.02 |
| *Probability for treatment effect* | *0.44* | *0.64* | *0.44* | *0.64* | *0.44* | *0.44* | *0.47* | *0.44* | *0.70* |

* Counts on 6/8 were one day before the second cover spray that included Closer in the Dow treatment and Beleaf in two FMC treatments.

Table 7. Codling moth seasonal activity, Columbus, Ohio, 2016.

| Date | Number of adults per pheromone trap in one week (mean of 3 traps) | Cumulative degree-days | | |
|---|---|---|---|---|
| | | After biofix 1 on 5/7 | After biofix 2 on 7/11 | After biofix 3 on 8/15 |
| 4/29 | 0.0 | - | - | - |
| 5/6 | 0.3 | - | - | - |
| 5/13 | 5.3 | 71 | - | - |
| 5/20 | 0.7 | 117 | - | - |
| 5/27 | 5.0 | 233 | - | - |
| 6/3 | 5.7 | 406 | - | - |
| 6/10 | 4.7 | 534 | - | - |
| 6/17 | 2.3 | 699 | - | - |
| 6/24 | 2.0 | 872 | - | - |
| 7/1 | 0.7 | 1031 | - | - |
| 7/8 | 0.3 | 1191 | - | - |
| 7/15 | 4.3 | 1373 | 111 | - |
| 7/22 | 5.0 | 1556 | 295 | - |
| 7/29 | 5.3 | 1756 | 495 | - |
| 8/5 | 2.7 | 1949 | 688 | - |
| 8/12 | 2.7 | 2149 | 888 | - |
| 8/19 | 3.7 | 2340 | 1079 | 109 |
| 8/26 | 4.0 | 2504 | 1243 | 273 |
| 9/2 | 4.7 | 2680 | 1418 | 448 |
| 9/9 | 3.0 | 2853 | 1592 | 622 |
| 9/16 | 3.0 | 2987 | 1725 | 755 |
| 9/23 | 1.3 | 3152 | 1890 | 920 |
| 9/30 | 0.0 | 3241 | 1980 | 1010 |
| 10/7 | 0.0 | 3345 | 2084 | 1114 |

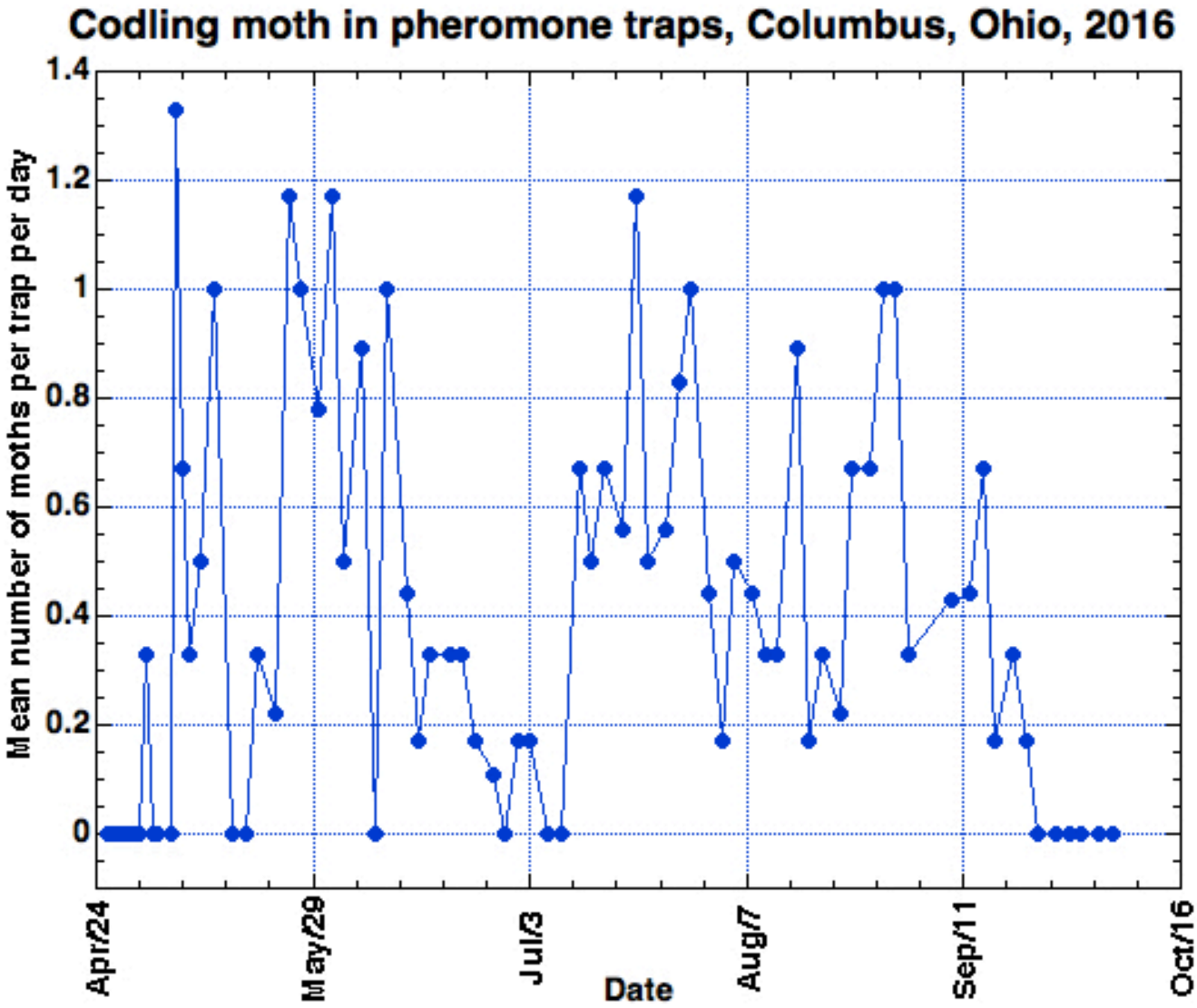


Figure 1. Seasonal trend in activity of codling moth adults as detected by three pheromone traps in apple orchard at Waterman Lab, Columbus, Ohio.