**Project Title:** Insecticidal control of leafhoppers in cherries

**Report Type:** Final report

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**Project Duration:** 2-Year

| | |
|---|---|
| **Total Project Request for Year 1 Funding:** | $81,166 |
| **Total Project Request for Year 2 Funding:** | $84,185 |
| **Total Request:** | $165,351 |

**Other related/associated funding sources:** None

**Budget**
**Primary PI:** Dr. Louis Nottingham
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| Item | 2020 | 2021 |
|---|---|---|
| **Salaries**[1,2] | $52,827 | $54,940 |
| **Benefits** | $18,373 | $19,108 |
| **Wages**[3] | $3,900 | $4,056 |
| **Benefits** | $366 | $381 |
| **RCA Room Rental** | | |
| **Shipping** | | |
| **Supplies**[4] | $4,500 | $4,500 |
| **Travel** | | |
| **Plot Fees** | $1,200 | $1,200 |
| **Miscellaneous** | | |
| **Total** | $81,166 | $84,185 |

**Footnotes:**

[1] Research assistant professor (Nottingham) at 2% FTE of $7,612.5 per month for 12 months.

[2] Postdoc at 100% FTE of $4,250 per month for 12 months

[3] Summer time slip at 20 hours per week for 13 weeks at $15.00 per hour.

[4] Supplies including potted cherries, greenhouse and colony supplies (cages, soil, pots), bioassay supplies (pipette tips, paper cups, lab sprayer supplies), and PCR diagnostic services.

**Objectives and Major Accomplishments:**

1. Perform initial screening on a wide range of insecticides (broad spectrum-conventional, soft-conventional, and organic) against leafhoppers for mortality and feeding suppression – **ACCOMPLISHED**.
    - Collection, handling, and bioassay protocols for *Colladonus reductus, Euscelidius variegatus,* and field-relevant mixes of leafhopper species were developed.
    - We identified conventional and organic insecticides that, when applied as direct contact spray treatments, caused high mortality of leafhoppers within 24-48 hours of application.
        - Conventional products resulting in 90-100% mortality were Asana XL (esfenvalerate), Malathion 5EC (malathion), Actara (thiamethoxam), Scorpion 35SL (dinotefuran, *not labeled for use on cherry leafhopper) Admire Pro (imidacloprid), Transform WG (sulfoxaflor), and Beleaf 50SG (flonicamid). Other products tested included Magister SC (fenazaquin), Bexar (tolfenpyrad), and Exirel (cyantraniliprole).
        - Organic products resulting in 90-100% mortality were PyGanic EC 1.4 II (pyrethrins) and Azera (pyrethrins + azadirachtin). Other organic products tested included Cinnerate (cinnamon oil), TetraCURB Organic (rosemary, clove, and peppermint oil), Entrust SC (Spinosad), Neemix 4.5 (azadirachtin), IAP 440 Oil (mineral oil), and an experimental formulation (MBI-306).
    - We tested particle films and insecticidal products for use as leafhopper repellents.
        - In bioassays, Celite 610 (diatomaceous earth particle film) Surround WP (kaolin clay particle film) were most effective for repellency. IAP 440 Oil at 1% concentration also repelled leafhoppers, but to a lesser degree

2. Determine whether X-infected leafhoppers are more susceptible to insecticides than uninfected leafhoppers – **NOT ACCOMPLISHED**.
    - Concurrent studies in the Northfield and Harper labs indicate that phytoplasma presence in wild-caught leafhoppers is too low for this objective to produce useful results.

3. Determine residual control timelines for the most effective foliar products – **ACCOMPLISHED**.
    - Most insecticides tested resulted in comparable leafhopper mortality regardless of residue age, and were effective as 1-day to 14-day residues. However, when significant differences existed, the insecticides performed better as fresher residues.
    - Greatest residue mortality of *C. reductus* was caused by Actara (88%), followed by Asana (58%), PyGanic (32%) and IAP 440 Oil (3%).
    - In a separate aged residue assay on *E. variegatus*, 6-day residues of Admire Pro and Actara caused comparable mortality (79% and 65% respectively).

4. Determine the potential for soil applications of systemic insecticides to provide long-term control of leafhoppers and disease transmission – **PARTIALLY ACCOMPLISHED**.
    - Soil drenches of Admire Pro and Platinum 75 SG (thiamethoxam) resulted in 51% and 73% mortality, respectively, of *E. variegatus* leafhoppers 6 days following application.
    - In a second type of systemic bioassay, Admire Pro caused high mortality in both *C. reductus* and *E. variegatus* leafhoppers.

**Table 1. Summary of insecticidal product effectiveness against leafhoppers in cherry via four different types of assays.** Per acre label rate is listed for each insecticide tested. A double underline indicates that two or more tests were completed for that product and rate.

Key:

| | |
|---|---|
| ■ Most Efficacious | (mortality >90%) |
| ▨ Efficacious | (mortality < 90% but significantly greater than check) |
| Not efficacious | (mortality not significantly greater than check) |

| | | Assay Type | | | |
|---|---|---|---|---|---|
| **Trade Name** | **Active Ingredient** | **Contact spray** | **Spray residue** | **Systemic** | **Repellency** |
| Actara | Thiamethoxam | ■ 2.75 oz | ▨ 2.75 oz[2] | | |
| Admire Pro | Imidacloprid | ■ 2.8 fl oz | ▨ 2.8 oz | ▨ 2.8 fl oz (leaf)<br>10.5 fl oz (soil) | |
| Asana XL | Esfenvalerate | ■ 14.5 fl oz | ▨ 14.5 fl oz[2] | | ▨ 14.5 fl oz |
| Azera* | Pyrethrins + azadirachtin | ■ 56 fl oz | | | |
| Beleaf 50SG | Flonicamid | ■ 2.8 oz | | | |
| Bexar | Tolfenpyrad | ▨ 27 fl oz | | | |
| Celite 610* | Diatomaceous earth | | | | ■ 50 lb[2] |
| Cinnerate* | Cinnamon oil | ▨ 60 fl oz | | | |
| Entrust SC* | Spinosad | 8 oz | | | |
| Exirel | Cyantraniliprole | 20.5 fl oz | | | |
| IAP 440 Oil* | Mineral oil | 1 gal | 1 gal | | ▨ 1 gal |
| Malathion 5EC | Malathion | ■ 44.8 fl oz | | | |
| Magister SC | Fenazaquin | ▨ 32 fl oz,<br>36 fl oz | | | |
| MBI-306* | Experimental | 15 fl oz,<br>20 fl oz | | | ▨ 15 fl oz,<br>20 fl oz |
| Neemix 4.5* | Azadirachtin | 16 fl oz | | | |
| Platinum 75 SG | Thiamethoxam | | | ▨ 3.76 oz (soil) | |
| PyGanic EC 1.4 II* | Pyrethrins | ■ 64 fl oz | ▨ 64 fl oz[2] | | |
| Scorpion 35SL[1] | Dinotefuran | ■ 10.5 fl oz | | | |
| Surround WP* | Kaolin clay | | | | ■ 50 lb[2] |
| TetraCURB Organic* | Rosemary oil | ▨ 256 fl oz | | | |
| Transform WG | Sulfoxaflor | ■ 2.75 oz | | | |

*OMRI-Listed product

[1] Product not labeled for use against cherry leafhoppers

[2] Product tested with and without 1% IAP 440 Oil

**Methods**:

*Collection and Transport*. Leafhopper adults were collected from weedy groundcover in organic commercial apple, cherry, and apricot orchards throughout the Columbia River Valley, WA. A modified leaf blower/vacuum with a 5-gallon paint strainer bag affixed to the tube was used to vacuum insects from clover, mallow, dandelion, and other weeds (Fig. 1, background). The bag was frequently emptied into a 12 inch by 24 inch mesh cage containing fresh vegetation to avoid sublethal injury to the insects (Fig 1, foreground). Vacuum sampling replaced collection via sweep net (2020-2021) because it caused less insect injury than the quick, jarring movements of the sweep net. In order of preference, adult insects used in these assays were *Colladonus reductus*, a mix of leafhoppers (mostly *C. reductus, some C. geminatus* and *Euscelidius variegatus*), and *E. variegatus* as were available in the field.

**Fig. 1.** Leafhopper collection method. Photo: Katlyn Catron.

Once returned to the lab, leafhoppers were sorted into vials from which they could be placed in assay arenas. Sorting was performed in a walk-in cold room to reduce leafhopper activity. Fresh leafhopper collections were made for each experiment.

*Bioassay Setup and Sampling*. Arenas were constructed using 16 oz plastic deli cups with moist soil and excised cherry leaves kept alive by constant contact with water in floral tubes (Fig. 2, left). Leafhoppers were moved into each arena at an appropriate time per assay. Each arena was sealed with a plastic lid with a mesh cutout (Fig. 2, center). Leafhoppers were allowed to acclimate to the arenas for one or more hours before treatments were applied. After treatments were applied, arenas were relocated to a greenhouse, and were stored there until leafhopper mortality was evaluated. Greenhouse temperatures were allowed to fluctuate naturally, but did not exceed 90 °F or drop below 60 °F.

To evaluate efficacy of insecticides, leafhoppers were rated as either alive or dead (“dead” leafhoppers were unable to walk). Moribundity was recorded in one assay as a measure of insects unlikely to recover from insecticide toxicity.

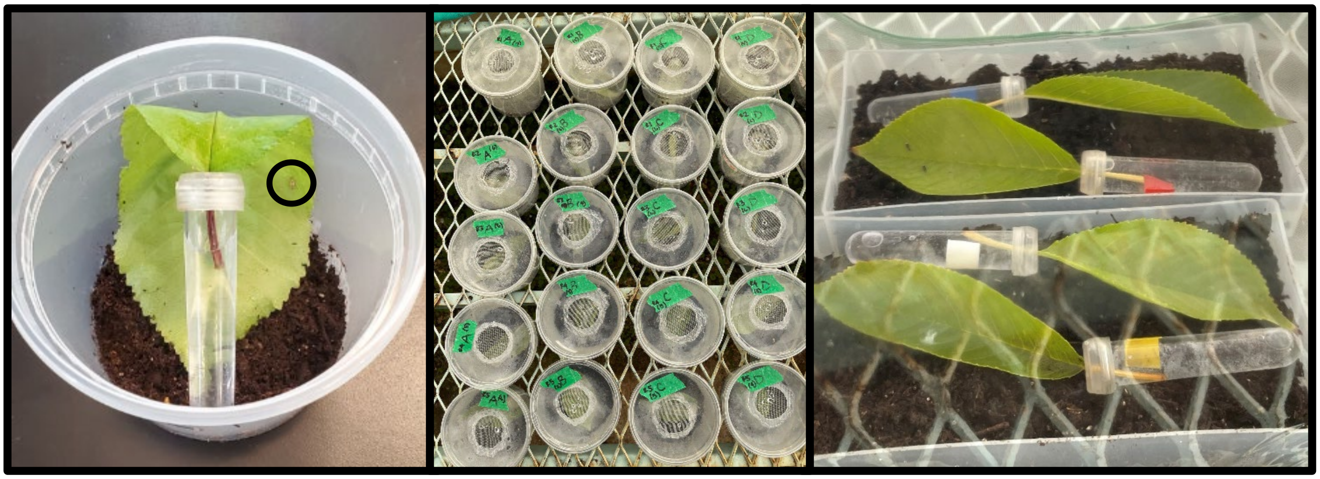

**Fig. 2.** Leafhopper bioassay arenas. **Left:** Closeup of contact spray assay arena without lid to show cherry leaf in floral tube, adult leafhopper (circled), and moist soil. **Center:** Treated contact spray assay arenas **Right:** Closeup of repellency assay arena showing four treated leaves in floral tubes on top of moist soil, with several *C. reductus* adults harboring on leaves.

**Table 2. Experimental design details for insecticide bioassays from 2020-2022.** Abbreviations: UTC = Untreated Control. N/A = not applicable. HAT or DAT = hours or days, respectively, after treatment. HAE or DAE = hours or days, respectively, after exposure.

| Year | Assay Type | A.I. Category | Treatments (Trt) | Residue Age | Target Insect | Insects/ Rep | Reps/ Trt | Metric | Metric Interval |
|---|---|---|---|---|---|---|---|---|---|
| 2020 | Contact spray | Conventional | UTC, TetraCURB Conc., Bexar, Transform, Asana, Malathion, Actara | N/A | *C. reductus* | 4-5 | 4 | % Mortality | 1 DAT |
| 2020 | Contact spray | Organic | UTC, Entrust, Neemix, TetraCURB Org, Cinnerate, Azera, PyGanic, Transform | N/A | *C. reductus* | 5 | 5 | % Mortality & moribundity | 1 DAT |
| 2021 | Contact spray | Conventional | UTC, Actara, Admire Pro, Transform | N/A | Mix | 5-6 | 5 | % Mortality | 1 DAT |
| 2021 | Contact spray | Organic | UTC, Asana, IAP 440 Oil, PyGanic | N/A | Mix | 8-10 | 5 | % Mortality | 1 DAT |
| 2022 | Contact spray | Conventional | UTC, Beleaf, Exirel, Admire Pro | N/A | *C. reductus* | 6 | 5 | % Mortality | 1 & 2 DAT |
| 2022 | Contact spray | Conventional | UTC, Beleaf, Exirel, Admire Pro | N/A | *E. variegatus* | 6 | 4 | % Mortality | 1 & 2 DAT |
| 2022 | Contact spray | Organic | UTC, MBI-306 (high rate), MBI-306 (low rate), Asana | N/A | *C. reductus* | 6 | 5-14 | % Mortality | 1 DAT |
| 2020 | Spray residue | Conventional | UTC, Actara, Admire Pro | 5 DAT | *E. variegatus* | 5-10 | 7 | % Mortality | 1 DAE |
| 2021 | Spray residue | Conventional | UTC, Actara, Asana, PyGanic | 1 HAT & 3, 7, & 14 DAT | Mix | 5-10 | 3-5 | % Mortality | 24-36 HAE |
| 2021 | Spray residue | Conventional | UTC, IAP 440 Oil, Asana + Oil, Actara + Oil, Admire Pro + Oil, PyGanic + Oil | 1 HAT, 3 DAT, & 5 DAT | Mix | 5-10 | 3-5 | % Mortality | 24-36 HAE |
| 2020 | Systemic - Soil Drench | Conventional | UTC, Platinum, Admire Pro | N/A | *E. variegatus* | 5-10 | 7 | % Mortality | 1 DAE |
| 2022 | Systemic - Leaf Uptake | Conventional | UTC, Admire Pro | N/A | *C. reductus* | 5-7 | 5 | % Mortality | 1 & 2 DAE |
| 2022 | Systemic - Leaf Uptake | Conventional | UTC, Admire Pro | N/A | *E. variegatus* | 5-6 | 4 | % Mortality | 1 & 2 DAE |
| 2021 | Repellency | Organic | UTC, IAP 440 Oil, Celite, Celite + Oil, Surround, Surround + Oil | N/A | *C. reductus* | >50 | 5 | # of insects on each leaf | 6 & 22 HAE |
| 2022 | Repellency | Organic | UTC, MBI-306 (high rate), MBI-306 (low rate), Asana | N/A | *C. reductus* | 10 | 5 | # of insects on each leaf | 1, 3, 5, & 7 DAE |

*Insecticide Exposure.* For contact spray assays, insecticide solutions were applied using hand-pump aluminum spray bottles through mesh lids to contact the leafhopper, leaf, and soil as would occur in the field. For the aged residue assays and systemic soil drench assay, treatments were applied to Lapins cherry trees (3/4") on Mazzard rootstock planted in 3.6-gallon injection molded pots. For aged residue assays, insecticide solutions were applied to the potted tree foliage using hand-pump aluminum spray bottles until just before runoff, and leaves were allowed to age in ambient outdoor conditions before being excised at predetermined intervals and exposed to leafhoppers in assay arenas described above. For the soil drench assay, prepared insecticide solutions were applied to the soil of Lapins cherry trees and the solutions allowed to translocate for five days before leaves were excised and exposed to leafhoppers as described above. For the systemic leaf uptake bioassays, insecticides were mixed per the label rate and used to fill the floral tubes into which excised cherry leaves were placed. Leaves were allowed to translocate the solution for approximately 1 hr before 5-10 leafhoppers were placed in the assay arenas and exposed to the systemically treated leaves.

*Repellents*: In 2021, particle films Surround (kaolin) and Celite (diatomaceous earth) were tested for repellency of leafhoppers. Potted Lapins cherry trees were sprayed to drip with treatments (see Fig. 11A x-axis for treatments). Treated trees remained outside for 24 hours after treatment (HAT) when selected leaves were removed for the first repellency assay. A second assay occurred 48 HAT. One leaf of each treatment was added to 1 of 6 replicate 12 inch x 12 inch mesh popup cages with plastic containers of moist soil lining the cage floor. A least 50 *C. reductus* leafhoppers were released into each cage. Six and 18 hours after release, leafhoppers were visually counted on each treated leaf. This experiment was performed twice; in the first experiment particle films were tested without oil, in the second, a 1% concentration IAP 440 oil was added to particle film treatments. A repellency assay with the same methods also occurred in 2022, but treatments tested included an experimental insecticide/repellent (MBI-306) at two concentrations, Asana, and an untreated control (UTC).

**Results:**

*Note**:** Insecticides are reported as trade names herein. Active ingredients are listed in Table 1.

*Contact Spray Assays.* In 2020, treatment with the conventional insecticides Asana, Malathion 5EC, and Actara all resulted in 100% mortality of *C. reductus* leafhoppers 24 HAT (Fig. 3). The organic insecticides PyGanic and Azera also achieved 100% mortality 24 HAT (Fig. 4). The conventional insecticide Transform WG resulted in 87.5% mortality in one bioassay (Fig. 3) and 96% mortality in a second when moribund individuals are considered dead (Fig. 4). The conventional materials Bexar and TetraCURB Concentrate (no longer manufactured) provided marginal control at 66.7% and 52% mortality, respectively (Fig. 3). The organic materials Cinnerate and TetraCURB Organic provided the next highest level of mortality for organic materials, both at ca. 72%, however many of these individuals were moribund (Fig 4.). The other organic insecticides provided marginal to poor control (Fig. 4).

In 2021, treatment with all conventional insecticides resulted in significantly greater mortality than the UTC (Fig. 5A). Two treatments, Admire Pro and Scorpion, reached 100% mortality at 24 hours after exposure (HAE). Actara, Transform, and Magister (high and low rates) resulted in 97%, 90%, 80%, and 72% mortality, respectively. Only one organic treatment, PyGanic resulted in high mortality of 98%, which was statistically comparable to the positive control Asana at 96% mortality (Fig. 5B). Treatment with IAP 440 Oil resulted in only 4% mortality, which was not significantly different from mortality in the control treatment (2%).

In 2022, 1 and 2 days of exposure of *C. reductus* to insecticides resulted in the following mortalities: Beleaf 90% and 90%; Admire Pro 72.7% and 86%; and Exirel 33.3% and 45.3%, respectively (Fig. 6, left). Mortality in the Exirel treatment was not significantly different from the UTC, but mortality in the Beleaf and Admire Pro treatments were significantly greater than the UTC at both timepoints. Exposure of *E. variegatus* for 1 and 2 days resulted in the following mortalities: Beleaf 21.3% and 36.3%; Exirel 30.4% and 78.8%; Admire Pro 71.7% and 100%, respectively (Fig. 6, right). After 24 hours, only mortality in the Admire Pro treatment was significantly greater than that in the UTC. After 48 hours, Exirel and Admire Pro caused significantly greater mortality than Beleaf and the UTC. In a separate assay, MBI-306 at the low and high rate caused *C. reductus* mortality that was not significantly different from the UTC at 1, 3, or 7 DAT. Asana, used as an industry standard in this assay, resulted in 95% mortality 1 DAT and 100% mortality 3 DAT.

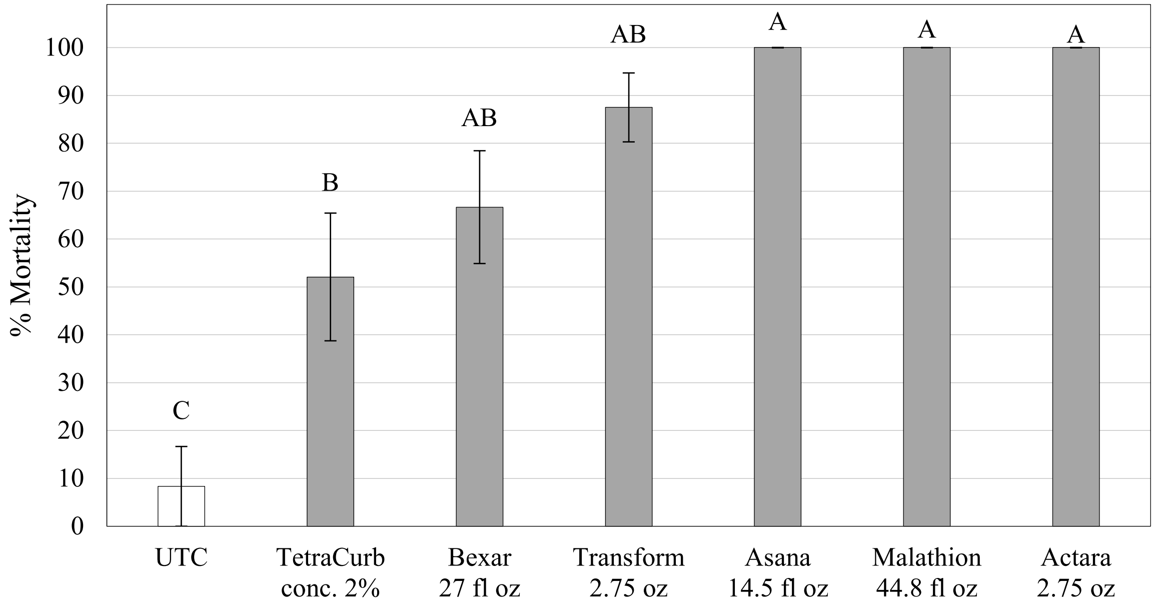

**Fig. 3.** 2020 Conventional Spray Contact Bioassay. Bars show average leafhopper mortality resulting from each insecticide. Bars not sharing a letter are significantly different according to Tukey's HSD ($P < 0.05$)

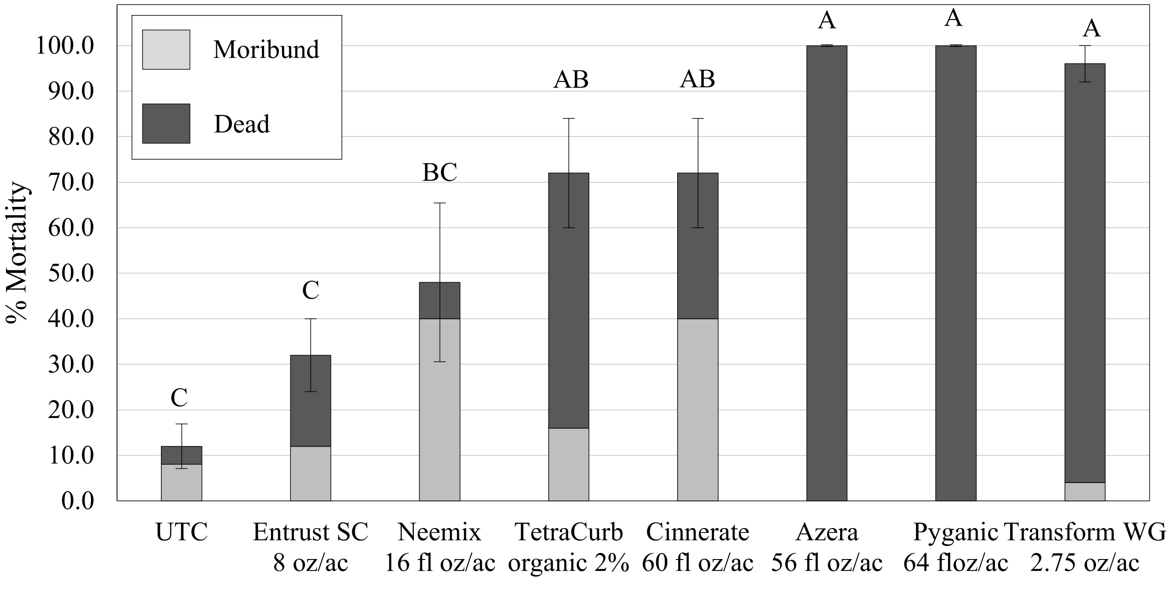

**Fig. 4.** 2020 Organic Spray Contact Bioassay. Bars show average leafhopper mortality resulting from each insecticide. Bars not sharing a letter are significantly different according to Tukey's HSD ($P < 0.05$)

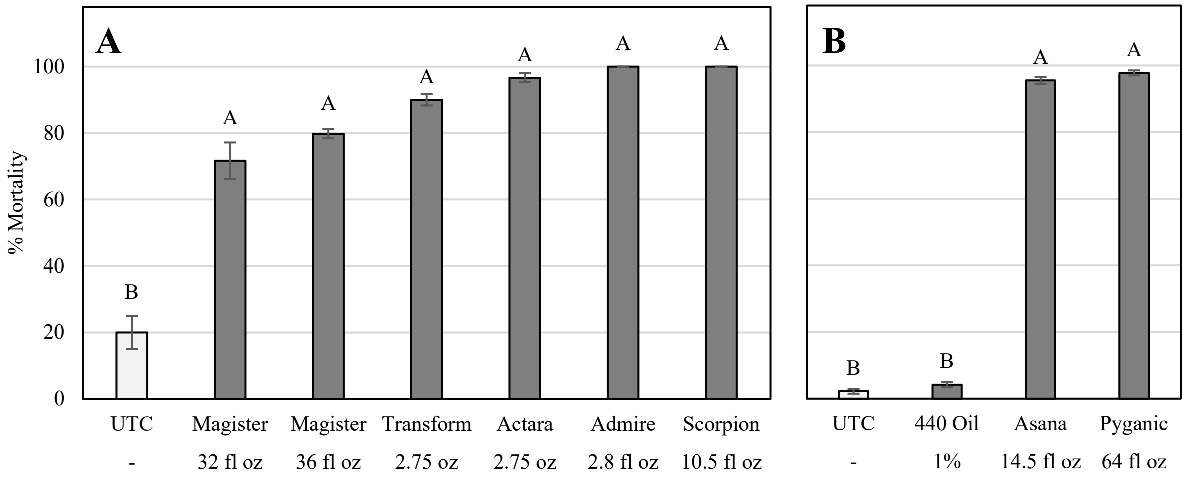

**Fig. 5.** 2021 Conventional (**A**) and organic (**B**) contact spray bioassay. Bars show average leafhopper mortality resulting from each insecticide. Per acre rates shown below each insecticide name. Bars not sharing a letter are significantly different according to Tukey's HSD ($p < 0.05$).

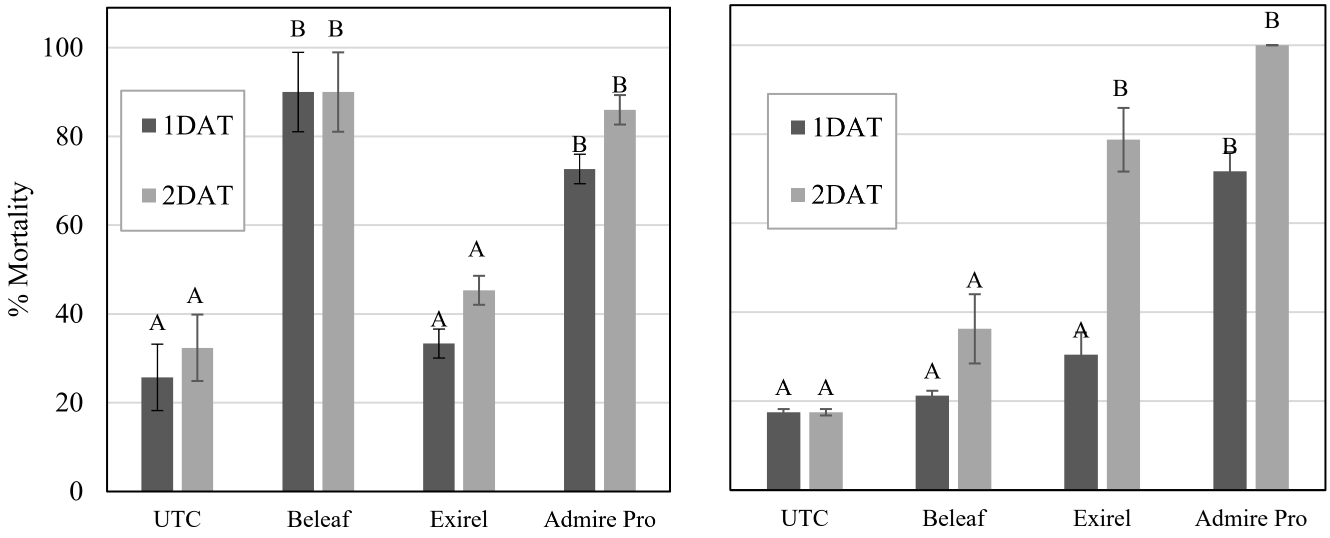

**Fig. 6.** 2022 Contact spray bioassay testing *C. reductus* (**left**) and *E. variegatus* (**right**) leafhoppers. Bars show average leafhopper mortality resulting from each insecticide. Per acre rates shown below each insecticide name. Bars not sharing a letter are significantly different according to Tukey's HSD ($p < 0.05$).

*Spray Residue Bioassays*. In the first spray residue bioassay of 2021, leafhopper mortality was different among treatments; Actara resulted in the highest overall mortality (88%), followed by Asana (58%) and Pyganic (32%) (Fig. 7B). Mortality did not decrease significantly over time for any treatment (Fig. 7A).

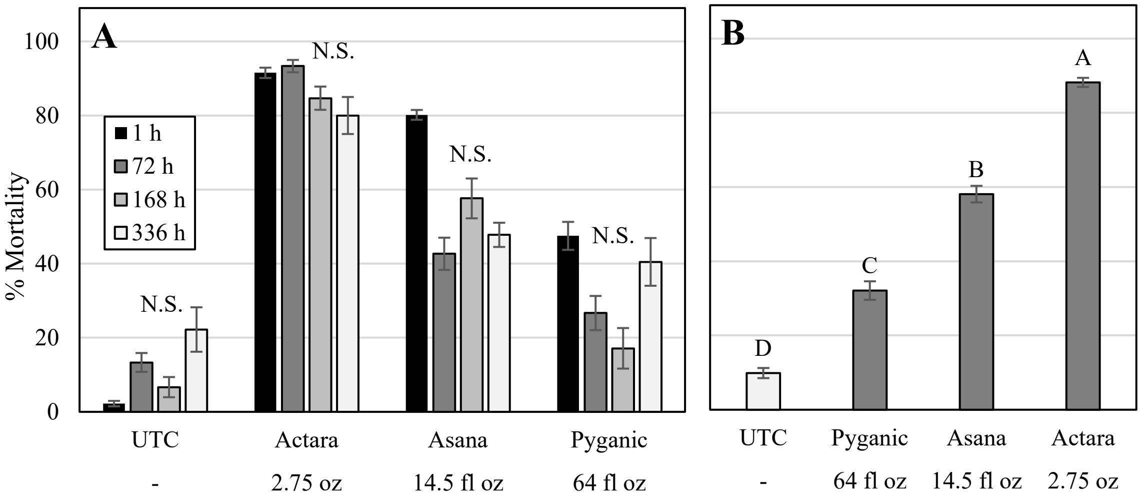

**Fig. 7.** 2021 A) Mortality of a field relevant mix of leafhoppers exposed to aged insecticide residues. B) Average leafhopper mortality across all residue ages. Per acre rates shown below each insecticide name. N.S. indicates no significant difference, and bars not sharing a letter are significantly different according to Tukey's HSD ($p < 0.05$).

In the second spray residue bioassay of 2021, leafhopper mortality was significantly different in the Asana + oil, Pyganic + oil, and UTC treatments (Fig. 8A). There were no significant differences in leafhopper mortality in the 440 Oil treatment, Actara + oil treatment, and Admire + oil treatment, indicating that these products performed similarly at all residue ages. When mortality was averaged across the experiment by treatment, Actara + oil and Asana + oil performed significantly better than all other treatments at 76% and 69% mortality, respectively (Fig. 8B). Experiment-wide mortality in the Pyganic + oil, Admire + oil, and 440 Oil treatments did not differ significantly from mortality in the UTC.

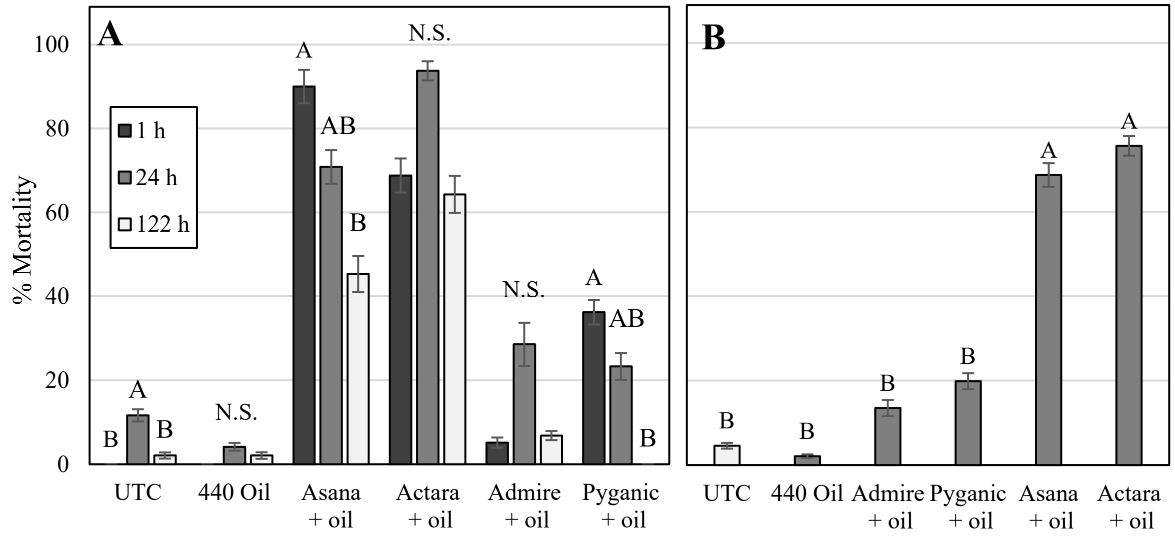

**Fig. 8.** 2021 A) Mortality of leafhoppers (mix of C. *reductus*, *geminatus*, and *E. variegatus*) exposed to aged insecticide residues. B) Average leafhopper mortality across all residue ages. N.S. indicates no significant difference, and bars not sharing a letter are significantly different according to Tukey's HSD ($p < 0.05$).

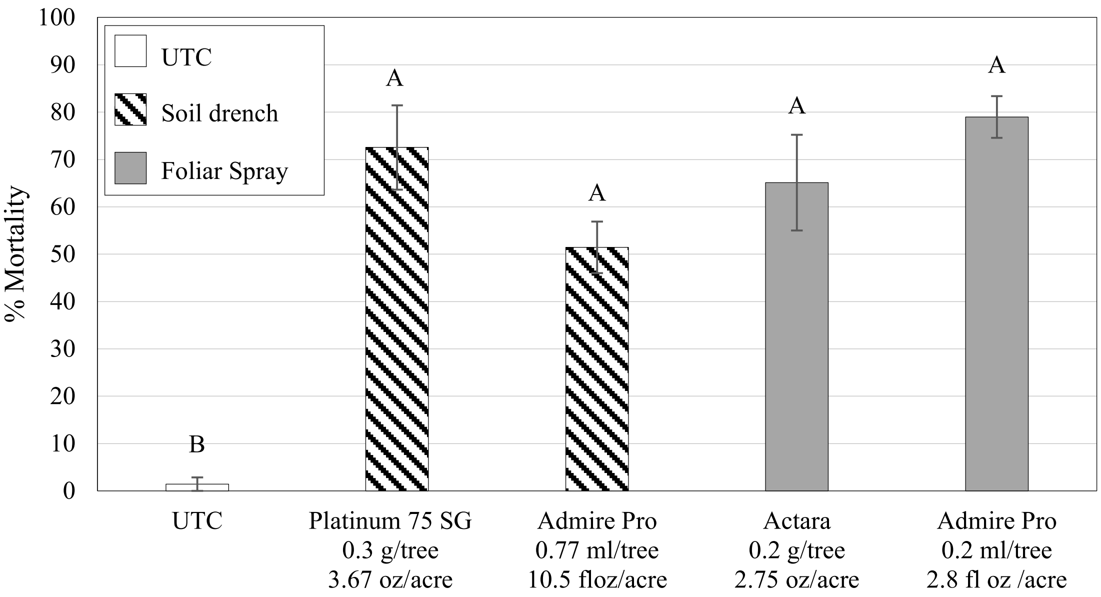

**Fig. 9.** 2020 Systemic soil drench and spray residue bioassay. Bars show average *E. variegatus* leafhopper mortality resulting from each insecticide product and application method. Bars not sharing a letter are significantly different according to Tukey's HSD ($P < 0.05$)

Results from the 2020 systemic soil drench bioassay and spray residue bioassay are combined in Fig. 9 (above). Mortality in *E. variegatus* leafhoppers exposed to 5 day foliar spray residues of Admire Pro (79%) and Actara (65%) was significantly greater than mortality in the UTC (1%).

*Systemic Soil Drench and Leaf Uptake Bioassays*. Mortality in *E. variegatus* leafhoppers exposed to soil drench-treated leaves after 5 days of translocation was greater in both insecticide treatments than in the UTC (Fig. 9). Platinum resulted in 73% mortality and Admire Pro resulted in 51% mortality, compared to the 1% mortality in the UTC.

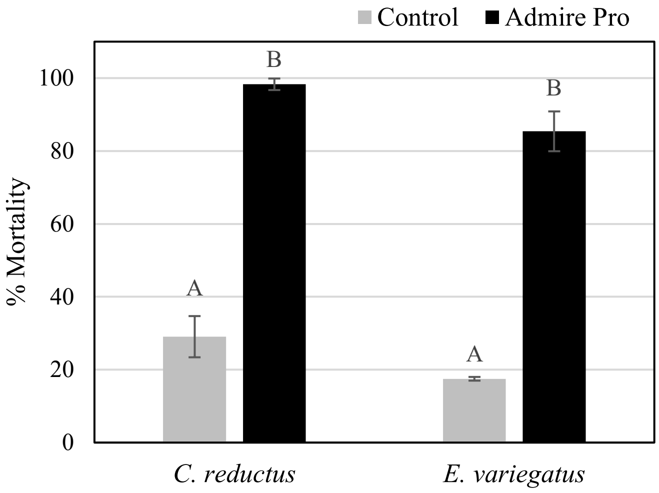

**Fig. 10.** 2022 Systemic leaf uptake bioassay. Bars show average leafhopper mortality resulting from exposure to systemic insecticide treatment. Bars not sharing a letter are significantly different according to Tukey's HSD ($P < 0.05$).

In the leaf uptake bioassay, mortality was significantly greater in the Admire Pro treatment than the UTC for both *C. reductus* (98% and 29%, respectively) and *E. variegatus* (85% and 9%, respectively) (Fig. 10).

*Repellency Assays*. Significantly fewer leafhoppers selected leaves treated with any combination of particle film (Celite [diatomaceous earth] or Surround [kaolin clay]) and oil compared to the UTC (Fig. 11, left). Leafhoppers chose oil-only treated leaves significantly less than untreated leaves, and leaves treated with any particle film significantly less than untreated or oil-only treated leaves. While untreated leaves harbored an average of 12 leafhoppers/leaf, oil-only treated leaves averaged 4, and particle film-treated leaves averaged fewer than 2. Similarly, significantly fewer leafhoppers, on average, harbored on leaves treated with Asana (0.1), MBI-306 at the low rate (0.4), or MBI-306 at the high rate (0.75) when compared to the untreated control leaves (1.7) (Fig. 11, right).

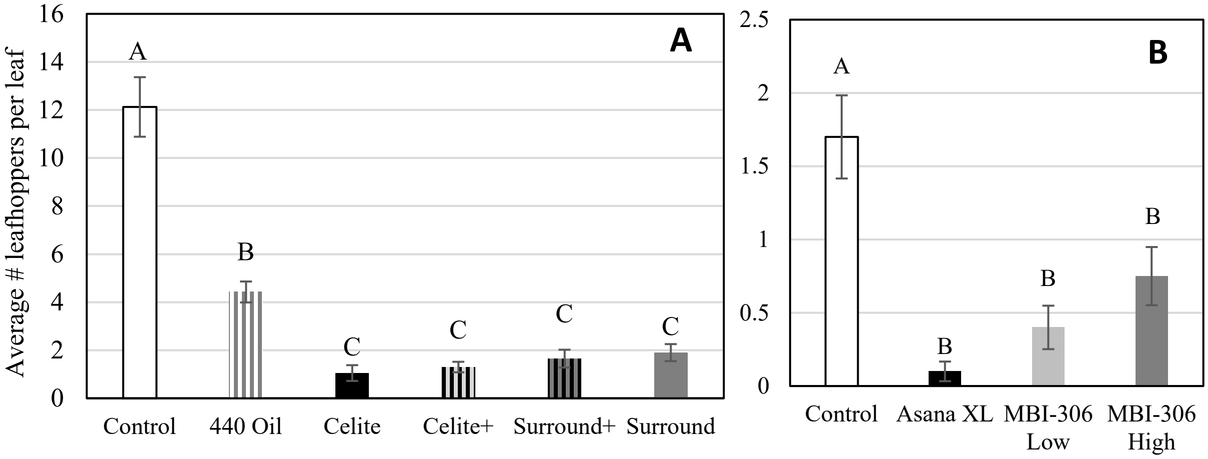

**Fig. 11.** Repellency assays in 2021 (**A**) and 2022 (**B**). Average number of *C. reductus* leafhoppers harboring on cherry leaves treated with repellent sprays or insecticides. Bars not sharing a letter are significantly different according to Tukey's HSD ($P < 0.05$). Product names followed by + indicate addition of 1% IAP 440 Oil.

**Discussion**:

From 2020-2022, we establish protocols for collection, handling, and bioassays for X-disease vectoring leafhoppers, *C. reductus*, *geminatus*, and *E. variegatus*. We tested nineteen commercially available insecticidal products via at least one form of exposure: direct contact, residues, or exposure to systemically treated leaves. Live leaves and soil were used in bioassay arenas to create a similar exposure situation to a field setting. Sprays into the arenas did not necessarily produce perfect contact with all leafhoppers or the entire leaf, which emulated actual field conditions.

We identified nine insecticides that were acutely efficacious (seven conventional, two organic) and four (two conventional, two organic) that were moderately efficacious upon direct spray contact. Residues of four insecticides (three conventional, one organic) performed moderately well with and without the addition of mineral oil and over the course of several days to weeks of aging. Through these aged residue assays, we were able to establish a protocol to test products and obtain more realistic estimates of their in-field performance over time without requiring a full field trial.

Prior to these assays, control of leafhoppers in cherries via systemic application methods had not been attempted. Two conventional insecticides caused significantly greater mortality than the check in both soil drench and leaf uptake assays. However, mortality was not remarkably high in the more field-realistic soil drench bioassay, and the high mortality in the leaf uptake bioassay should be interpreted cautiously as that setup is highly artificial. The need for accurate soil drench information is crucial to help control X-disease transmitting leafhoppers in nursery trees. Our results indicate that imidacloprid and thiamethoxam may have a role in those control efforts.

Finally, repellency assays indicated that kaolin clay and diatomaceous earth strongly discouraged leafhoppers from harboring on freshly treated leaves. Both particle films were highly efficacious for repellency of leafhoppers. Repeat assays with residues aged in ambient field conditions would provide more field-relevant information to growers trying to discourage leafhopper harborage in their trees.

Because most of the effective materials identified in this project are broad-spectrum in nature, conventional growers and organic growers risk driving insecticide resistance and flaring secondary pests such as aphids and mites. Although these outcomes are less concerning than the transmission of X-disease, future work should have the goal of developing more selective approaches that will eventually replace some, if not all, broad-spectrum insecticides. IPM research areas may include leafhopper and disease phenology, selective pesticides and repellents, and management of broadleaf weed hosts.

Three years of field collections of *C. reductus, E. variegatus*, and other leafhopper adults present in cherry orchards highlighted the variety of hardiness and tolerance of these insects. *Colladonus reductus* is a known competent vector of X-disease, so attempts were made to include as many individuals as possible in bioassays. However, it is a frail insect and proved difficult to transport, handle, and keep alive in bioassay results. *Euscelidius variegatus* seems a hardier insect, easier to transport, and perhaps more tolerant of insecticidal exposure, but is also found in high numbers throughout the field season and is hypothesized to be a competent X-disease vector. Therefore, to produce the most field-relevant data possible, multiple leafhopper species were evaluated in these assays.

We made several important phenological observations throughout the field seasons of 2020, 2021, and 2022. We noted that adult leafhoppers of interest are present from April to October at the very least, and even November in 2022. Interestingly, the final generation of *C. reductus* adults (occurring in October) was the largest generation seen in 2021. This means that control methods will need to be implemented through the fall to protect trees from X-disease transmission when leafhoppers are at their greatest numbers.

## Executive Summary

**Project Title:** Insecticidal control of leafhoppers in cherries

**Key words:** cherry, leafhopper, chemical, control, insecticide

## Abstract

Leafhopper collection method using a modified leaf blower/vacuum. Photo: Katlyn Catron.

Chemical control of leafhoppers is understudied and at a critical point in Pacific Northwest cherries as growers try to prevent catastrophic losses due to X-disease. Prior this study, insecticidal recommendations for leafhopper control were several decades out of date or from geographically unsuitable areas. Between 2020 and 2022, we evaluated 19 insecticides for control of several species of field-relevant leafhoppers using four application methods: direct contact spray assays, residue assays, systemic assays, and repellency assays.

We identified conventional and organic insecticides that caused very high mortality of leafhoppers within 24-48 hours of direct spray application. Conventional products resulting in >90% mortality were Asana XL (esfenvalerate), Malathion 5EC (malathion), Actara (thiamethoxam), Admire Pro (imidacloprid), Transform WG (sulfoxaflor), and Beleaf 50SG (flonicamid). Organic products resulting in >90% mortality were PyGanic EC 1.4 II (pyrethrins) and Azera (pyrethrins + azadirachtin). Fresher residues of insecticides (<3 days) performed better than older residues (>7 days) in some products, but mortality of leafhoppers exposed to residues of Actara, Admire Pro, Asana, and PyGanic was higher than control mortality at all residue ages, meaning insecticide residues continue to kill field-relevant leafhoppers for days to weeks after application in simulated field conditions.

Insecticides applied systemically via soil drenches or leaf uptake bioassays, including Admire Pro and Platinum 75 SG (thiamethoxam), caused significantly greater mortality than the control treatments, suggesting their potential for use for controlled circumstances such as in nursery trees. Celite 610 (diatomaceous earth particle film) Surround WP (kaolin clay particle film), Asana XL, and IAP 440 Oil successfully repelled leafhoppers from harboring on treated leaves, indicating that particle films may have a role in dissuading leafhoppers from landing on orchard or nursery trees.

In this study, we have updated insecticidal recommendations for leafhoppers in cherries, established effective protocols for collecting and transporting leafhoppers, and developed assays to assess insecticides and repellents via multiple application methods. These protocols can be utilized by future researchers to expeditiously evaluate additional control methods in this system.