FINAL PROJECT REPORT

Project Title: Overwintering survival and management of the Spotted Wing Drosophila

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Total Project Request: **Year 1:** $20,662

Other funding sources: None

WTFRC Collaborative expenses: none

Budget 1
Organization: OSU MCAREC **Contract Administrator:** Dorothy Beaton
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Item	Year 1
Salaries[1]	9,126
Benefits[2]	5,476
Wages[3]	2,000
Benefits[4]	160
Equipment	0
Supplies[5]	2,400
Travel[6]	1,500
Total	20,662

Footnotes:
[1] 25% FTE Technician
[2] benefits at 60%
[3] student (time slip) summer help
[4] benefits at 8%
[5] includes traps, emergence cages, field supplies
[6] within state travel to field sites

Objectives:

Objective 1. Assess overwintering survival of the spotted wing drosophila in various cherry producing areas in Oregon.

Objective 2. Conduct insecticide efficacy tests in sweet cherry to start to develop management guidelines or this pest.

Objective 3: Extend information to industries in a coordinated manner

Methods

Objective 1. Assess overwintering survival of the spotted wing drosophila in various cherry producing areas in Oregon

Laboratory studies: Our objectives were to determine survival of *D. suzukii* adults and pupae under two general scenarios. The first scenario simulated constant mild overwintering temperatures. The second scenario, mild temperatures with a seven day freeze period, was designed to mimic conditions found at high-elevation or inland production sites. SWD will be reared to pupal and adult stages. One day old adults and puparia (minimum 100 each) will be used to test survival of *D. suzukii* under five winter temperature conditions found in fruit production areas in the Pacific Northwest. Initially all individuals will be exposed to mild overwintering conditions for 2 mo. at 50°F and 8:16h L:D. After initial exposure, individuals will be subjected to five climates: 36°F (here we will subject flies at 23°F for one week to take into account a major freeze event in the middle of the two month period), 36, 39, 43, 46 and 50°F, and 8:16h L:D for two mo. A third mild two month period will represent early spring conditions (50°F at 12:12 h L:D). Two hundred individuals at each life stage will be subjected to typical average temperature in the fruit production areas.

Field studies: These sites will be located near weather stations that collect air and soil temperatures. Laboratory-reared SWD will be acclimated using the mild fall regime and placed in emergence cages in the Willamette Valley, Hood River, The Dalles and Milton Freewater in commercial cherry orchards during December. Three emergence cages will be placed in each location and each emergence cage will contain 100 adult and 100 pupae SWD. Adults will be placed in semi-protected cages within each emergence cage in order to simulate protected micro-habitats sought by free-living overwintering individuals. Cages containing both life stages will be left in the field until March-April and the number of surviving adults and emerged pupae recorded.

Objective 2. Conduct insecticide efficacy tests in sweet cherry to start to develop management guidelines or this pest. Insecticide efficacy tests will be conducted to evaluate insecticidal management of the spotted wing drosophila. . Insecticides chosen for this study will be based upon several factors including local grower preference of cherry fruit fly products and results from similar trials to be conducted in California during 2010. Each treatment will be replicated 4 times in a RCB.

Objective 3: Extend information to industries in a coordinated manner.
This pest affects a wide variety of fruit crops. Teaching materials, new research information and seasonal observations will be made available via an online SWD workspace maintained by the OSU Horticulture Department.

Significant findings:

- Our work shows that adult flies can survive up to 88 days at temperatures of 50°F constant, with a slight increase in mortality when a 7 day freeze period is included. It is expected that longevity will be shorter at constant temperatures below 50°F.
- When pupae are subjected to similar temperatures, emerged adults can live to 105 days at constant 50°F and 103 days with a seven day freeze period. Lower survival rates are expected at lower temperatures.

- The fact that only female individuals survived to the conclusion of the experiment may have significant implications during the following season. First, pest management scouts will have to adapt early trapping to specifically search for females. Second, it is noted that female individuals that are unmated may still lay eggs but the proportion of viable eggs is unknown.
- The delay in initiating the field overwintering study has allowed other cooperators to participate this winter. This aspect of study will be conducted in OR, WA, and BC.
- Malathion ULV appears to be effective against the spotted wing drosophila.
- Delegate, entrust, malathion, carbaryl and pyrethroids have been demonstrated to be effective against SWD in field-lab studies.
- Our successful outreach program for the Mid-Columbia cherry industry in concert with this research mitigated SWD problems in this area this past growing season.

Results and Discussion:
Objective 1. Laboratory Study: In all four experiments individual SWD survived for the longest periods at 50°F (Figs. 1-4). SWD survival rates were similar at 36°F and 39°F and were significantly lower than survival rates at 43°F and 46°F. Survival was significantly lower for all temperatures compared to the 50°F treatment.

Adults at 50°F gradually died with no freeze (Fig. 1) over a period of 84 days and displayed linear mortality over the experimental period. The simple regression function of adult survival on time at 50°F estimated that adults will survive to 88 days at 50°F. Adults at colder constant temperatures than 50°F survived shorter periods. The majority of flies died within 8 days at 36 and 39 °F and 20 days at 43 and 46°F. Mortality rates for these four temperatures dramatically decreased after 8 and 20 days.

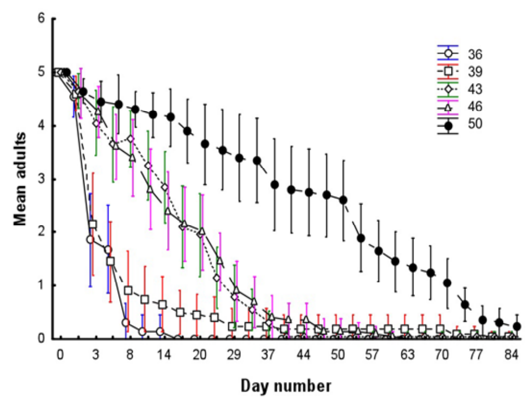

Figure 1. Mean survival of Spotted Wing Drosophila per cup

Adult mortality with the 7 day freeze period (Fig. 2) displayed an approximate straight line over the experimental period. The simple regression function of adult survival on time at 50°F estimated that adults will survive to 85 days at 50°F. Adults at colder constant temperatures than 50°F survived shorter periods. The majority of flies died within 5 days at 36 and 39 °F and 20 days at 43 and 46°F. Mortality rates for all temperatures dramatically increased during the 7 day freeze period, but decreased thereafter (Fig. 2).

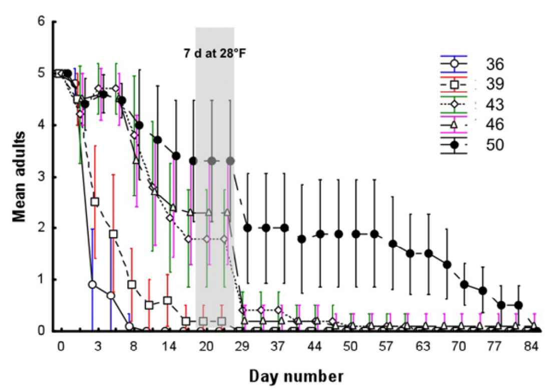

Figure 2. Mean survival of Spotted Wing Drosophila per cup. The freeze period is indicated by the transparent bar.

Pupae with no freeze (Fig. 3) emerged during the first 20 days of the experiment as adult individuals. Subsequently adult mortality after day 20 at 50°F displayed a linear relationship. The simple regression function of pupae developing to adults and subsequent adult survival on time at 50°F estimated that adults emerging from pupae will survive to 105 days at 50°F. Adults emerging from pupae at colder constant temperatures than 50°F survived shorter periods. We believe that the majority of individuals probably died while in the pupal stage within 8 days at 36 to 46°F. Mortality rates for these four temperatures remained high to 37 days. All individuals died by 60 days at temperatures below 50°F.

In the treatment where pupae were subjected to a 7 day freeze period (Fig. 4), adults emerged during the first 20 days of the experiment until the onset of the 7-day freeze period. No adults emerged after the freeze period. Subsequently adult mortality after day 20 at 50°F displayed an approximate straight line. The simple regression function of adult survival on time at 50°F estimated from this function is that adults will survive to 103 days at 50°F. Adults held at constant temperatures below 50°F survived shorter periods.

The majority of flies died within 8 days at all temperatures. Mortality rates for all temperatures did not show a dramatic increase as seen when adults were subjected to the 7 day freeze period. One notable finding from our work is that the only individuals surviving to the conclusion of the experimental period were females.

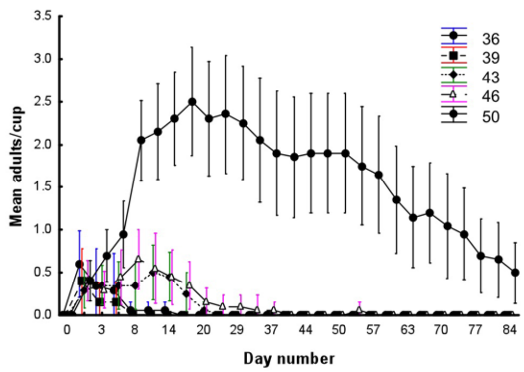

Figure 3. Mean Spotted Wing Drosophila adults started from the pupal stage per cup. The number of adults initially increased as they emerged from the pupal stage, and then decreased due to mortality.

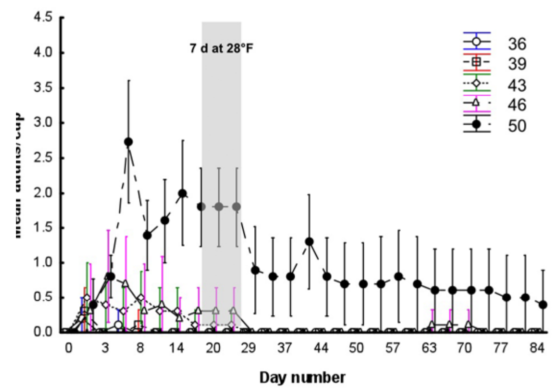

Figure 4. Mean Spotted Wing Drosophila adults started from the pupal stage per cup. The number of adults initially increased as they emerged from the pupal stage, and then decreased due to mortality. The freeze period is indicated by the transparent bar.

Objective 1. Field studies: Overwintering studies were not conducted in 2009/2010 because flies were not available until January. This study will be conducted this winter. We will work with Dr. Elizabeth Beers, WSU TFREC, and Dr. Howard Thistlewood, Agriculture and Agri-Food Canada, Summerland, BC, and we all follow the same procedures. This will greatly expand our study and applicability of our outcomes.

Objective 2. Efficacy trials:
Note: This first test was not originally planned but the opportunity presented itself and we undertook it. On 27 May, 2010, an experiment was conducted to evaluate the potential of aerial applied Malathion ULV against the spotted wing drosophila. Three paired blocks were treated with malathion ULV applied by fixed-wing (Shearer Sprayers) at a rate of 16 oz/A. It was applied approximately at 10:30 AM, with winds at 0.5-1.8 MPH, and 58 F. Before application, we placed in the trees:
1) Oil-sensitive spray cards (8 per tree; 4 along the outside of the canopy at the top, mid, bottom and ground level, and 4 in the inside of the canopy at the top, middle, bottom and ground. One card per location on a tree or ground), 4 trees per site, 12 trees total, 96 cards total,
2) Sticky cards containing live SWD adults glued onto their backs placed around the bottom of the tree canopy and ground (flies on cards were exposed to the aerial treatment), and,

3) Small screened cages containing live SWD adults placed around the bottom of the tree canopy and ground (flies were exposed to treated air but realize that the screen probably acted as a barrier to airflow and/or serve as a surface that captures ULV droplets that may subsequently provide a source of residue for the caged flies to contact).

The plane made 3 passes at 100 ft intervals over each of the 3 test sites. One hour after application, we removed these items plus treated and untreated leaves collected from several areas within the canopy and brought everything back to the entomology laboratory at MCAREC. The leaves were used to line small plastic deli containers that were screened to provide ventilation. Flies were added to these containers to evaluate residual control.

Results and Discussion:
ULV droplets on spray cards. The average number of aerosol malathion droplets recorded on spray cards was no different on cards placed in the inside of tree canopies compared with the number of droplets on cards placed on the outside of tree canopies (Fig. 5). Deposition was relatively uniform from tree top to bottom and ground.
Sticky cards with immobilized flies had 28.5% corrected mortality 22 hours after exposure and 48% corrected mortality at 36 hours indicating that about half of stationary flies received a toxic dose of malathion ULV.
The cages with flies had fly corrected mortality of 71% 22 hours after exposure.
Mortality of flies confined to containers with treated leaves had 12% corrected mortality after 16 hours of exposure, 80.7% corrected mortality after 43 hours of exposure to treated leaves. We observed 12% mortality in the untreated controls at the 43 hr mark.

Based upon laboratory evaluations of malathion ULV applied to cherries by fixed-wing at 16oz/A, it appears that when applied under good conditions to tree canopies that are not completely grown together, malathion ULV could likely be a useful management tool for this insect. Obviously, the only way to say with certainty that malathion ULV will protect fruit from SWD infestation is to apply this product to cherries with populations of SWD present and evaluate fruit for infestation. However, given that we have observed adequate mortality of flies placed in the field and in containers with treated leaves, malathion ULV should be considered as another tool in the SWD arsenal for cherry growers to be combined with ground sprays of products recommended for SWD control.

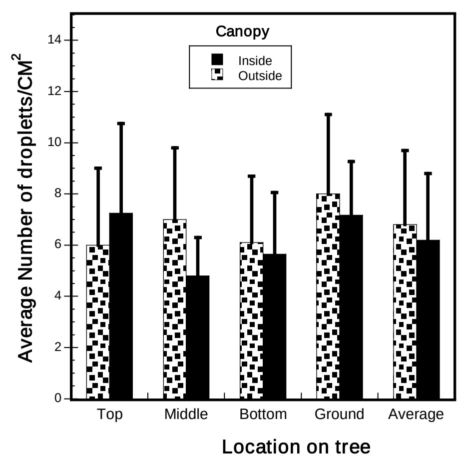

Figure 5. Average number of malathion ULV droplets/cm2 on oil-sensitive spray cards.

Additional efficacy research was conducted at two sites to evaluate promising insecticides for control of spotted wing drosophila (SWD) on sour cherries and sweet cherries. The sour cherry site was a large commercial orchard located near Gaston, OR and the sweet cherry site was located at the Oregon State University Mid-Columbia Agricultural Research & Extension Center (MCAREC), Hood River, OR. Populations of SWD were not present during the test period at these locations so we could not assess insecticidal effects directly in the field. Instead, trees were sprayed with an airblast sprayer and then leaves and fruit were brought back to the laboratory where they were exposed to adult SWD to evaluate adult mortality, egg laying and emergence of adults.

Tests conducted on both types of cherries were conducted using the same protocol. Treatments (Table 1) were applied with an airblast orchard sprayer to individual trees. Each treatment was replicated 4 times. After treatment, leaves and fruit were collected and brought back to the laboratory. For the leaf assays, leaves were taped to the inside sides and bottoms of plastic deli cups and then 10-15 flies were added to each cup before they were covered with lids (Fig. 6). Both the cups and lids had screen mesh that covered holes added for ventilation. Fruit assays comprised of 5 fruit per tree, 20 per treatment, and each set of five fruit were fastened to the bottom of deli cups with clay (Fig. 7). Ten-fifteen adult SWD were added to the cups. The cups were covered then with lids and mortality was assessed over time. All flies were removed after 2-3 days. Egg-laying was assessed by counting and recording the number of breathing tubes (=spiracles, a visible egg structure) per fruit. Adult emergence was evaluated later from one test.

Figure 6. Example of cup lined with leaves for residual assay.

Figure 7. Example of fruit assay container.

Table 1. Products tested and rate per acre applied.

Active ingredient	Product	Rate/Acre
malathion 56%E	Malathion 5EC	4 pints
acetamiprid 70%WP	Assail 70WP	3.4 oz
carbaryl 43%F	Sevin XLR	2 qts
spinetoram 25%WG	Delegate WG	4.5 oz
spinosad 80%WP	Entrust	2.5 oz
Experimental 1	Cyazypyr	X
imidacloprid 17.4%F	Provado 1.6	6-8 fl oz
lamda-cyhalothrin	Warrior II	2 oz
malathion 79.5%	Malathion 8F	3 pints
Experimental 2	ARY-0556-001	XX
control	untreated	--

Results indicate that several insecticides, including malathion, spinosad, spinoteram, and lamda-cyhalothrin, provide relatively quick mortality of flies placed on treated foliage and fruit (Figs. 8-11).

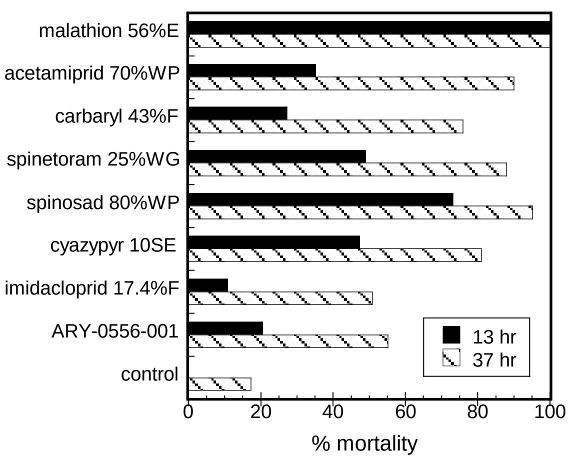

Figure 8. Mortality of adult SWD 13 and 37 hours after being placed on leaves collected from treated trees, Gaston.

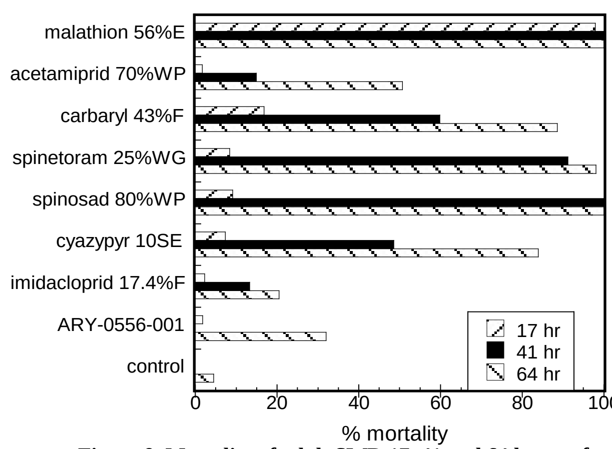

Figure 9. Mortality of adult SWD 17, 41 and 64 hours after being placed on fruit collected from treated trees, Gaston.

Carbaryl is moderately toxic to flies and is slower acting. The neonicitinoids acetamiprid and imidacloprid were not that effective when compared with efficacy of the above products in terms of mortality and preventing egg-laying (Figs 3-7). However, it appears that acetamiprid, imidacloprid and the Experimental 1 treatments have systemic activity because of the reduction of adult SWD that emerged from treated fruit relative to the number of eggs laid in these fruit (Fig. 12). It is possible that these products may have use as post-harvest cleanup sprays.

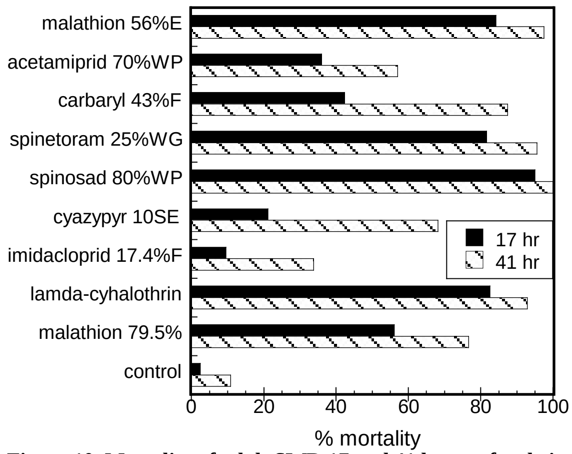

Figure 10. Mortality of adult SWD 17 and 41 hours after being placed on leaves collected from treated trees, MCAREC.

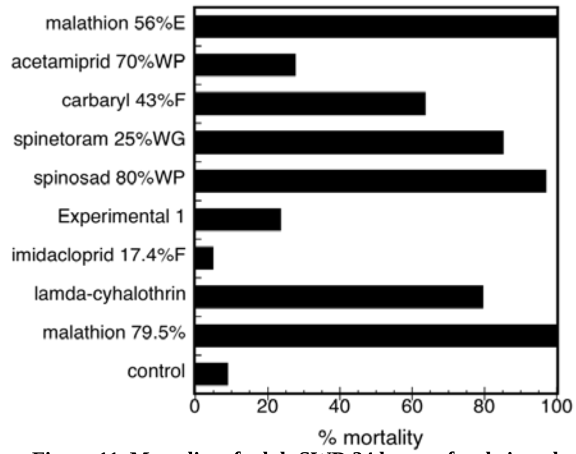

Figure 11. Mortality of adult SWD 24 hours after being placed on fruit collected from treated trees, MCAREC.

It appears that several insecticides, including malathion, spinosad, spinoteram, lamda-cyhalothrin, and carbaryl, which are effective against the western cherry fruit fly, *Rhagoletis indifferens*, will also control SWD. This means that cherry growers currently have a few tools at their disposal until other effective control measures are discovered.

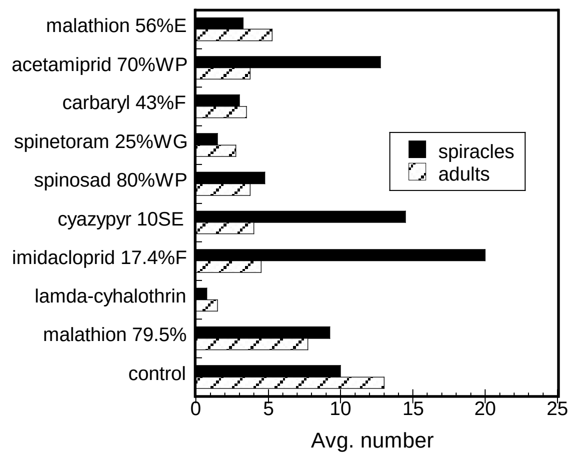

Figure 12. Abundance of eggs laid and adults that emerged from treated fruit, MCAREC.

Objective 3: Extend information to industries in a coordinated manner.
Our outreach efforts including meetings with growers and field men led to the creation of a SWD management plan for Mid-Columbia cherries. We developed list of preferred and emergency materials along with a trapping and monitoring plan that alerted growers when and where flies were found. Growers and field men received this information weekly through updates from our Extension personnel. No SWD-induced load rejections or harvest infestations were reported from the Mid-Columbia cherry district. Teaching materials, new research information and seasonal observations are available via an online at our SWD workspace maintained by the OSU Horticulture Department at: http://swd.hort.oregonstate.edu/