FINAL PROJECT REPORT

Project Title: Insecticide management of spotted wing drosophila in cherry orchards

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Other funding sources

Agency Name: USDA SCRI SWD Grant: Biology and management of spotted wing drosophila on small and stone fruits: Duration 4.5 years

Amt. awarded: $598,144 / $564,959

Total Project Funding: $18,003

Budget History:

Item	Year 1: 2012
Salaries	
Benefits	
Wages	$11,520
Benefits	$1,005
Equipment	
Supplies	$600
Travel	$440
Plot Fees	$4,437
Miscellaneous	
Total	**$18,002**

RECAP ORIGINAL OBJECTIVES

1. *Determine effective insecticide rates for spotted wing drosophila management in cherry orchards*
    a. The original goal of this project was to conduct insecticide-rate studies in a large block of commercially managed Regina cherries maintained at MCAREC. The methodology included releasing large quantities of adult SWD to coincide with the insecticide applications and then assess the impact of these insecticides to protect fruit from infestation. Unfortunately, we were not able to obtain funding from the commission to reimburse MCAREC for using these trees. Instead, we conducted field-lab assays using four-single tree replicates to determine residual activity of insecticides against SWD. We evaluated efficacy of adult female SWD exposed to leaves and fruit out to 14 days after treatment (DAT).

2. *Evaluate if intensive sampling and monitoring for SWD will allow growers to incorporate GF-120 into their cherry IPM programs*
    a. This objective was modified for 2 reasons, 1) we detected SWD infested fruit in the earliest maturing blocks in Dallesport, and 2) we could not locate growers who would risk using GF-120 in light of the early documented SWD damaged fruit. Therefore, we took the opportunity to intensively monitor fruit from 12 commercial orchards; 3 early ripening blocks in both Dallesport and Hood River and 3 late harvest blocks in both The Dalles and Parkdale. We compared two types of apple cider baited traps at two densities and examined fruit for SWD eggs during the ripening period. In all 12 cases, we trapped and examined fruit at the orchards' periphery and interior.

SIGNIFICANT FINDINGS

Adult female spotted wing drosophila were used to evaluate the effectiveness and residual activity of various insecticides. Their response varied depending upon substrate (treated leaves versus fruit) and insecticide. The pyrethroids are the most efficacious and long lasting products tested. Spinosyns (Delegate and Entrust) are slower acting. Malathion provides quick knockdown but has extremely short residual activity.

Intensive trapping generally detected adult SWD before eggs were observed in cherry fruit. It is quite possible that with a better trap, increased trap numbers and possibly fruit sampling, growers and fieldmen may be able to use other products for cherry fruit fly when SWD is not present. Further research is needed to substantiate this.

RESULTS & DISCUSSION

1. *Insecticides for spotted wing drosophila management*

Various insecticides were applied to three ripening cherry trees per treatment using an airblast sprayer calibrated to deliver 100 GPA while traveling at 1.6 MPH. The application date was 24 July, 2012. Afterwards, we collected four leaves from each of the three replicates/treatment on 1, 3, 7, 10 and 14 days after treatment (DAT). Individually leaves were encased in small petri dishes containing five adult female SDW that were exposed to the bottom leaf surface plus a small piece of artificial diet for humidity control. Mortality was assessed after 24 and 48 h of exposure.

Adult female SWD mortality and egg production were also assessed by exposing adult female SWD to fruit collected from the same trees. At 1, 7 and 14 DAT, 5 fruit per replicate were collected and placed into individual 1 oz portion cups. A single fly was added and then the cup was covered. Adult mortality was assessed at 24 h. The number of eggs laid in fruit was counted under a stereomicroscope. Average % mortality and average number of eggs laid was then calculated for each treatment.

The pyrethroids Warrior and Danitol and the OP malathion provided the best knockdown activity after 24h exposure 1DAT (Table 1). The pyrethroids provided the best residual activity with 90+ % mortality 10 DAT after 24 h exposure and over 85% mortality 14 DAT with a 48 h exposure to treated leaves (Tables 1 & 2). Malathion provided only marginal kill 3 DAT and mortality in this treatment was not different from levels of mortality observed in the untreated control leaves by 7 DAT. Leaves treated with Delegate or Entrust SC provided intermediate control at the 24 h assessment. However, the 48 h assessment revealed an increase in mortality of these products indicating that these spinosyns are not fast-acting when flies are exposed to treated leaves (Table 2). The nicotinoid insecticide, Belay, was not effective. Figures 1 (24 h) and 2 (48 h) presented this information as % corrected mortality, which factors in the levels of mortality observed in the control.

Interestingly, the effect of treated fruit as a substrate on mortality of adult SWD is somewhat different from what was observed on flies exposed to treated leaves. In this case, the spinosyns Delegate and Entrust and the carbamate carbaryl killed 100% of the flies within 24 h of exposure 1 DAT while during the same assessment period, only 67, 67 and 50% (respectively) of flies confined on leaves 1 DAT died, indicating these products were not as efficacious on foliage as compared with treated fruit (Tables 1 & 3, Fig. 3). Leaves treated with carbaryl were not as toxic as treated fruit to female SWD and fruit treated with carbaryl was more toxic than malathion 1 and 7 DAT (Table 3, Fig. 3). As in the leaf assay, Belay was not effective. This supports previous research indicating that nicotinoid are not effective against SWD.

Interpreting these results should be made with caution because of the differences in how adult female SWD flies responded to treatments on leaves versus fruit. As indicated, certain products such as spinosyns and carbaryl performed better when fruit were used as the assay substrate while the pyrethroids and malathion looked best when leaves were used. Another cautionary note is based upon how fast the residual activity of malathion declines. Results here indicate this product is active for 3 days or less. Growers that rely on malathion ULV with extended intervals may run into problems with infestations, especially late season.

Overall, these results parallel results from similar studies that indicate the pyrethroids, OPs and spinosyns have activity against SWD although residual control varies among the products. It may also be possible to use high rates of carbaryl as a rotational product for resistance management but not rely on it as a stand-alone product until further testing is conducted.

2. *Evaluate if intensive sampling and monitoring for SWD will allow growers to incorporate GF-120 into their cherry IPM programs*

This research was conducted in 12 commercially managed blocks of cherries. These sites were located in the two cherry districts, Dallesport/The Dalles and Hood River/Parkdale, OR. Within each district, three blocks were located in early-ripening areas (Dallesport and Hood River) and three blocks were located in late-ripening blocks (The Dalles and Parkdale).

At each orchard, we deployed 16 traps, all baited with apple cider vinegar; eight were the standard 32 oz deli trap with holes on the sides and the remaining were “Haviland” traps, a Rubbermaid container with a screen lid which has been shown to capture greater numbers of SWD. Half the traps at each block were deployed along a suspect border; the remainder was placed in the interior of the cherry block. Traps were deployed at two densities; one trap per unit area versus three traps on three adjacent trees. The density component of this study allowed us to determine if we gain precision (first detection of SWD in traps, number of SWD per trap) by placing more traps in a localized area. The 192 traps were checked weekly.

Fruit samples were also collected and assessed for infestation. Each sample consisted of of 250 fruit collected haphazardly from periphery and interior trees. A sub-sample was observed for eggs under a stereo dissection scope, another subset was crushed crushed and inspected for infestation using the brown-sugar float method developed for cherry fruit fly (CFF) and a third subset was held in containers to rear out SWD. Phenology stages, color and soluble solids of the ripening cherries were recorded at sampling. Monitoring of traps and fruit sampling will continue through harvest

Female flies were trapped in all 12 blocks while male flies were trapped in 10 blocks. The first flies captured in a block were female in 6 blocks, males in two blocks and both sexes were first captured simultaneously in blocks 4 times (Fig. 4). There was no difference in when the first flies were captured between traps placed in border versus interior trees (Table 5). Flies were captured in border trees 7 times and in traps inside the orchard 9 times. In six instances, flies were detected on border and interior trees simultaneously. We caught significantly more flies in the Haviland traps compared with the deli cups. The average seasonal total for flies captured in the Haviland trap and deli cup was 42 versus 16, indicating that the Haviland trap is a superior trap. Additionally, the Haviland traps were more likely to capture the first fly in a block (Table 6). Regarding using traps in clusters to detect the first fly in a block, single traps captured the first fly 4 times while the clusters of three traps captured the first fly 13 times (Table 7). This indicates that the more traps placed in an orchard increases the likelihood one will capture the first fly.

In general, adult SWD were detected in traps (10 of 12 sites) in the study sites before eggs (1 of 12 sites) or larvae in fruit (1 of 12 sites). We observed SWD eggs in fruit collected from 5 blocks. In general, we captured adults in traps before we observed eggs in associated fruit (Fig. 5). Adults were detected in traps 7, 15, 28 and 34 days before we detected eggs in fruit on those 4 blocks. At one site in Dallesport, we detected eggs 7 days before we captured the first adult SWD in that block. In that sample, the average CTIFL fruit color was 1.9 indicating this block was attacked early in the ripening process. We suspect this damage was caused by the overwintering generation that survived a mild winter. The average CTIFL color of fruit in the other four blocks where we observed SWD eggs ranged from3.1-4.8. Six of 12 blocks had fruit in the green-pink stages when the first flies were captured.

Table 1. Mean % mortality (±SEM) of adult female *Drosophila suzukii* exposed to treated foliage for 24h 1, 3, 7, 10, or 14 after treatment (DAT).

		% Mortality (±SEM) of adult female *Drosophila suzukii*				
		DAT				
Insecticide	Rate/acre	1	3	7	10	14
Warrior II	2.56 oz	100.0±0.0a	100.0±0.0a	95.0±5.0a	90.0±5.8a	90.0±2.9a
Danitol 2.4 EC	16 oz	100.0±0.0a	96.7±3.3a	93.3±4.4a	90.0±7.6a	75.0±7.6a
Danitol 2.4 EC	21 oz	95.0±2.9a	100.0±0.0a	90.0±7.6a	100.0±0.0a	80.0±10.4a
Delegate WG	4.5 oz	66.7±19.2b	45.0±7.6b	18.3±3.3bc	11.7±1.7b	13.3±4.4b
Entrust SC	6.4 oz	66.7±11.7b	38.3±1.7bc	23.3±11.7b	23.3±6.7b	25.0±10.4b
Malathion 8 EC	80 oz	98.3±1.7a	53.3±15.9b	3.3±1.7c	16.7±12.0b	8.3±6.0b
Belay	6 oz	10.0±5.0d	10.0±2.9cd	5.0±2.9c	3.3±3.3b	11.7±9.3b
Carbaryl 4 L	2 qt	50.0±23.1c	33.3±4.4bc	13.3±4.4bc	20.0±13.2b	15.0±2.9b
Control	--	3.3±1.7d	5.0±2.9d	3.3±1.7c	3.3±3.3b	1.7±1.7b

Table 2. Mean % mortality (±SEM) of adult female *Drosophila suzukii* exposed to treated foliage for 48h 1, 3, 7, 10, or 14 after treatment (DAT).

		% Mortality (±SEM) of adult female *Drosophila suzukii*				
		DAT				
Insecticide	Rate/acre	1	3	7	10	14
Warrior II	2.56 oz	100.0±0.0a	100.0±0.0a	96.7±3.3a	96.7±3.3a	98.3±1.7a
Danitol 2.4 EC	16 oz	100.0±0.0a	98.3±1.7a	95.0±5.0a	93.3±6.7ab	85.0±7.6ab
Danitol 2.4 EC	21 oz	96.7±3.3ab	100.0±0.0a	91.7±8.3a	100.0±0.0a	86.7±8.8c
Delegate WG	4.5 oz	90.0±5.0ab	73.3±4.4ab	35.0±8.7bc	43.3±6.0c	31.7±11.7c
Entrust SC	6.4 oz	90.0±2.9ab	63.3±4.4b	66.7±8.8ab	46.7±6.7bc	36.7±13.6bc
Malathion 8 EC	80 oz	98.3±1.7a	63.3±19.6b	3.3±1.7d	18.3±11.7cd	16.7±7.3c
Belay	6 oz	23.3±8.8c	16.7±6.0cd	8.3±1.7dc	6.7±6.7d	16.7±14.2c
Carbaryl 4 L	2 qt	66.7±17.6b	50.0±5.8bc	51.7±17.4b	51.7±8.8	21.7±3.3c
Control	--	6.7±1.7c	8.3±1.7d	3.3±1.7d	3.3±3.3d	8.3±6.0c

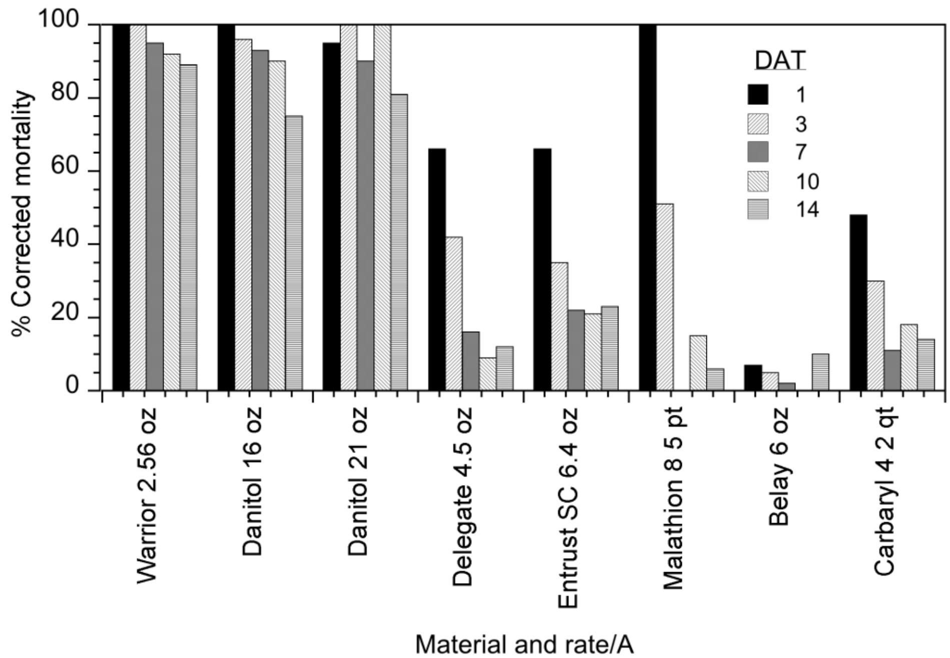

Fig 1. Mortality of adult spotted wing drosophila 24h after being placed on treated leaves 1, 3, 7, 10 and 14 days after treatment (DAT).

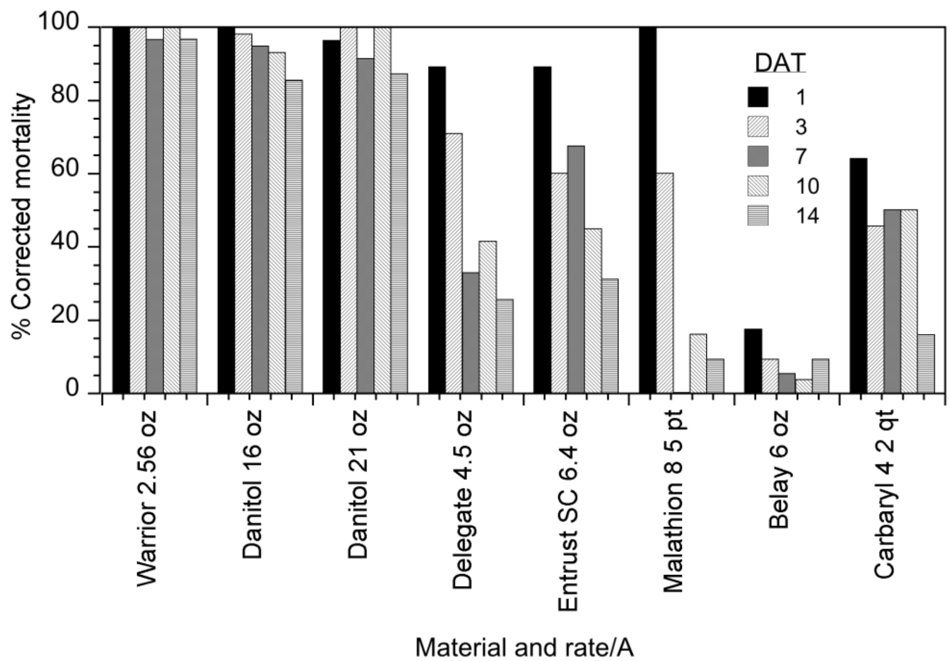

Fig 2. Mortality of adult spotted wing drosophila 48h after being placed on treated leaves 1, 3, 7, 10 and 14 days after treatment (DAT).

Table 3. Mean % mortality (±SEM) of adult female *Drosophila suzukii* exposed to treated cherry fruit for 24h 1, 7, or 14 after treatment (DAT).

		% Mortality (±SEM) of adult female *Drosophila suzukii*		
		DAT		
Insecticide	Rate/acre	1	7	14
Warrior II	2.56 oz	80.0±11.5ab	66.7±17.6ab	53.3±6.7abc
Danitol 2.4 EC	16 oz	80.0±0.0ab	33.3±17.6	20.0±11.5bc
Danitol 2.4 EC	21 oz	86.7±6.7a	53.3±6.7ab	46.7±26.7abc
Delegate WG	4.5 oz	100.0±0.0a	80.0±11.5ab	40.0±20.0abc
Entrust SC	6.4 oz	100.0±0.0a	73.3±13.3ab	86.7±6.7a
Malathion 8 EC	80 oz	73.3±17.6ab	20.0±11.5bcd	20.0±20.0c
Belay	6 oz	33.3±24.0bc	6.7±6.7cd	20.0±11.5bc
Carbaryl 4 L	2 qt	100.0±0.0a	86.7±6.7a	73.3±6.7ab
Control	--	0.0±0.0c	0.0±0.0d	13.3±6.7c

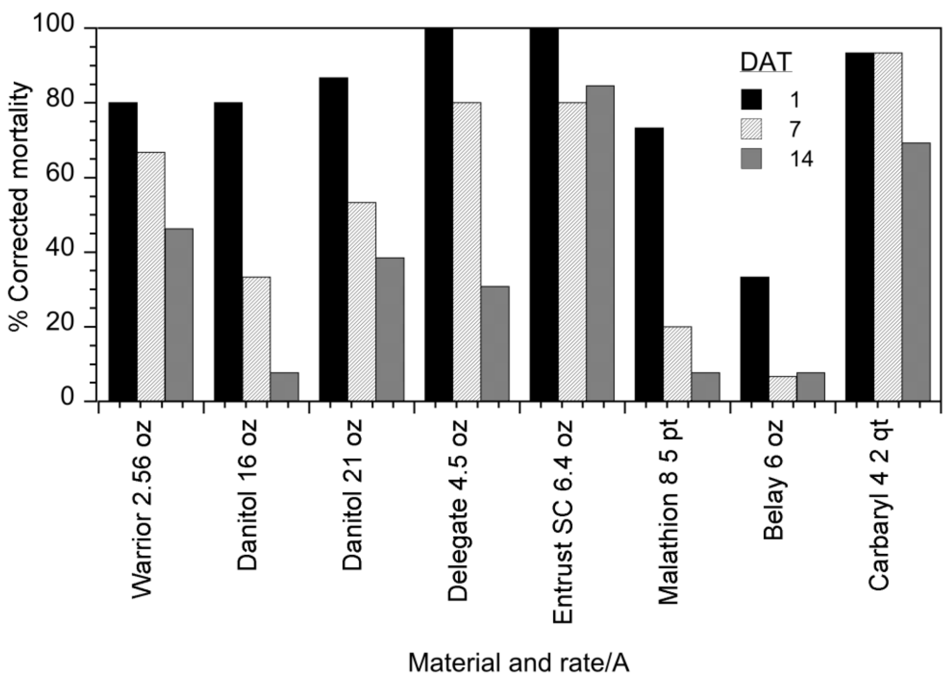

Fig 3. Mortality of adult spotted wing drosophila 24h after being placed on treated fruit 1, 7 and 14 days after treatment (DAT).

Table 4. Mean number (±SEM) of eggs laid 24h after exposure in cherry fruit collected 1, 7, and 14 days after treatment (DAT).

		Mean (±SEM) number of eggs		
		DAT		
Insecticide	Rate/acre	1	7	14
Warrior II	2.56 oz	0.3±0.2e	0.1±0.1c	2.6±0.9d
Danitol 2.4 EC	16 oz	0.4±0.4de	2.0±0.8bc	4.6±0.9bcd
Danitol 2.4 EC	21 oz	0.6±0.3cde	0.6±0.5c	2.7±0.5dc
Delegate WG	4.5 oz	2.0±0.9cde	2.7±1.2bc	7.1±2.8bcd
Entrust SC	6.4 oz	3.5±1.3bc	2.2±1.6c	12.3±4.8ab
Malathion 8 EC	80 oz	3.4±1.6bcd	12.9±4.0a	22.5±4.0a
Belay	6 oz	9.8±3.0ba	16.1±8.8a	25.3±4.8a
Carbaryl 4 L	2 qt	2.3±0.5cde	1.4±0.8c	9.4±0.4abc
Control	--	14.8±2.8a	9.0±2.0ab	23.9±4.5a

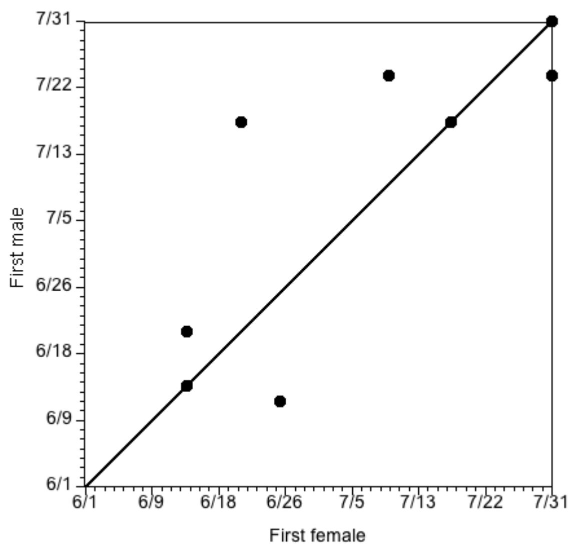

Figure 4. Relationship between first adult male and female SWD captured in ACV traps in the same block.

Table 5. Influence of orchard location on first capture of *Drosophila suzukii*

	Sex	
Field position	Female	Male
Border	5	2
Interior	6	3
Same time	1	5

Table 6. Influence of trap type on first capture of *Drosophila suzukii*

Trap type	Sex	
	Female	Male
Deli cup trap	3	0
Haviland trap	7	5
Same time	2	5

Table 7. Influence of trap density on first capture of *Drosophila suzukii*

Trap density	Sex	
	Female	Male
Single trap	3	1
Three traps	8	5
Same time	1	4

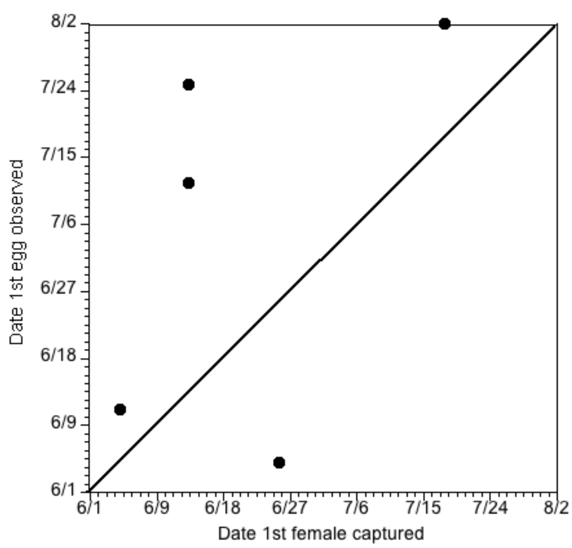

Figure 5. Relationship of first female captured in ACV baited traps with first observed egg.

EXECUTIVE SUMMARY

Project Title: Insecticide management of spotted wing drosophila in cherry orchards

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Early detection of commercial cherry fruit infested with spotted wing drosophila (SWD) and an agreed upon budget reduction forced changes to be made in how the two objectives were carried out. Instead of being able to buy the crop of commercial cherries at MCAREC for use in determining effective rates of a few insecticides, we looked at residual activity of several classes of insecticides to determine how long these were active against SWD. In this case, we determined that the pyrethroids provided the longest residual activity and that malathion was extremely short-lived. This later observation translates into a caution for growers that might want to rely on malathion ULV to provide extended control. It appears that when SWD is present, growers should not rely on this product exclusively. Similarly, while Delegate and Entrust are effective, they are not nearly as fast acting as pyrethroids and OP insecticides. This study has also indicates that high rates of carbaryl may provide some control of SWD, especially as a rotational material.

The original proposal also had a component in it to look at whether intensive trapping and monitoring for SWD would allow growers to use GF-120 for cherry fruit fly control if and when SWD was not detectable in the orchard. This project was modified after we detected SWD infested cherries in two early season blocks and we were not able to find growers that would risk their crops by using GF-120 for cherry fruit fly. So, instead of working in 4 orchards with intensive sampling in GF-120 and insecticide treated blocks, we expanded our study to 12 locations that represented early and late districts in Dallesport/The Dalles and Hood River County. Overall, we were able to detect flies in orchards with traps (16 traps per orchard) before we detected infested fruit. We also demonstrated that using more traps is better for detecting the first flies in cherry orchards. We also demonstrated that there is a better trap than the clear deli cup for detecting the first fly and for monitoring purposes.

Based upon these studies, we feel that with accurate monitoring, it is likely that growers may be able to treat for cherry fruit fly when SWD is not present. Before this happens, more research is needed.