FINAL PROJECT REPORT

Project Title: Spotted Wing Drosophila management on sweet cherry

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Other funding sources

Agency Name: NIFA-SCRI
Amt. awarded: $95,726 (ca. $20,000/year)
Notes: Walton et al. 2010. Funded 5-year project, 9/1/2010 through 8/31/2015

Total Project Funding: $125,000

Budget History:

Item	**2011**
Salaries	20,000
Benefits	7,500
Wages	38,400
Benefits	29,472
Equipment	0
Supplies	7,628
Travel	22,000
Miscellaneous	**0**
Total	**125,000**

Objectives

1) Determine seasonal phenology in the fruit-growing areas of eastern Washington.
2) Compare trapping systems for optimal use in large-scale monitoring.
3) Determine stage at which cherries are susceptible to attack.
4) Determine effectiveness of pesticides for SWD on cherry.

Significant Findings

- As of mid-October, trap catches are considerably lower in 2011 than in 2010. In 2010, the highest numbers were found north of I-90; in 2011, higher numbers are being caught south of I-90.
- Of the six SWD trap types tested, the Haviland trap (hardware cloth top) caught significantly more SWD than all other types; the modified Haviland (holes in sides) caught much less than the standard Haviland, indicating the large diffusion area may be responsible. However, this trap was also the least selective for other *Drosophila* and Diptera.
- Spinosad insecticides are highly toxic to SWD, however, activity drops off with decreasing rate; the 1.25 oz rate of Entrust was less effective than the maximum label rate. Using spinosad as a toxicant, several other sugar-based baits caused similar (high) levels of mortality as GF-120. Success, Entrust, Warrior and Endigo caused high levels of mortality, but Delegate allowed more survival in a field-lab bioassay.
- GF-120 reduced fruit infestation by SWD in comparison to an untreated check, whereas Entrust eliminated it completely.

Results and Discussion

<ins>SWD Trapping Program.</ins> Meetings with fieldmen were held in Brewster and Yakima in April of 2011 to determine optimal trap locations. Traps were deployed in April, and regular weekly checks began in early May. All traps were barcode labeled, and a barcode scanner was used in the lab when the samples were processed, and checked against the known list of trapcodes. Each trap had a duplicate (either a duplicate trap for the Contech, or a sample cup for the other trap types) with matching barcodes; one trap was in the field, and on in lab at any given time. The duplicate trap was cleaned out and re-baited at the end of the week in preparation for deployment the following week.

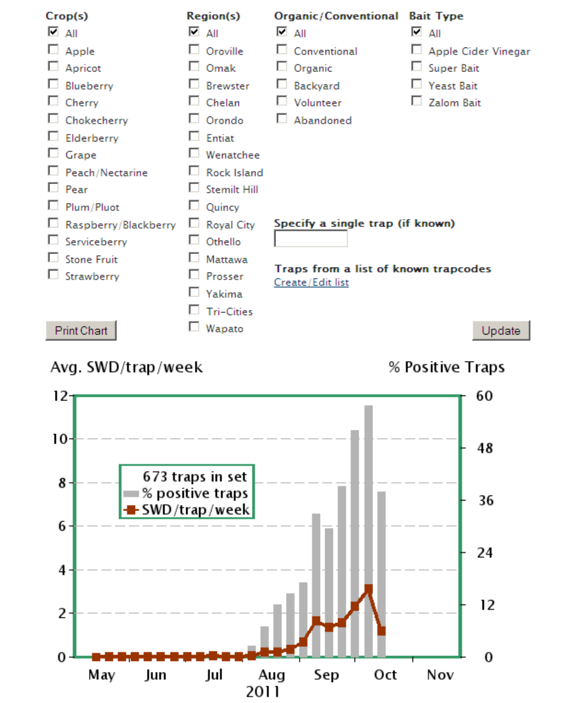

Fig. 1. Filter selection and sample graph from SWD website

The contents of the traps were counted in the laboratory using a binocular microscope. SWD males and females were recorded separately, and other drosophila were counted in order to assess trap selectivity. The counts were recorded directly into a computer, and uploaded at the end of each working day to the WSU SWD website (http://extension.wsu.edu/swd/). The table on the front page gave a list of growing regions in eastern Washington, and the alert status of each region (whether the first fly had been caught in that region). First catches were posted on the day the sample was processed, and an update was added to the blog at the end of the week.

In addition to the alert table, website users could graph the contents of the database, either using the entire database, or by filtering the contents by crop, region, or growing regime (Fig. 1). This facility allowed access to the database information while preserving the anonymity of individual operations. Users could also create custom lists of their own traps using individual trap codes.

Overall, trap catches were considerably lower in 2011 than in 2010 (Fig. 2). The reasons are not known, but the cold snap in late November of 2010 may have drastically reduced the overwintering population, and the delayed development of fruit trees due to cold weather may also have negatively affected development of SWD. Unlike 2010, trap catches south of I-90 are double on the average of those north of I-90 (0.30 v. 0.61/trap/week).

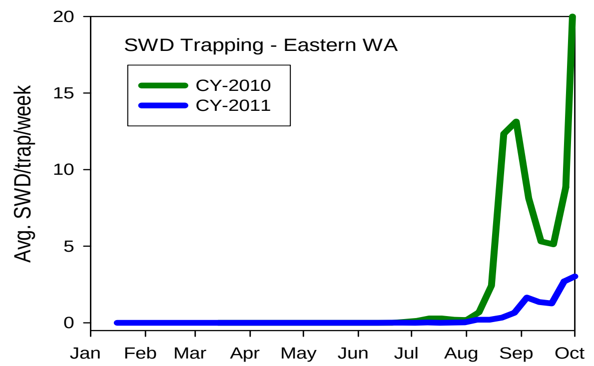

Fig. 2. SWD trap catches (2010 versus 2011).

<u>Trap Type Comparison.</u>

Six standardized trap types were compared in six replicate orchards in eastern Washington. The same traps were also tested by other SCRI participants in other regions and crops. The trap types consisted of different sizes, shapes, and colors of containers, and varying numbers and positions of holes for diffusion of the bait odor and entrance of flies (Fig. 3). All traps had 150 ml bait load, with the exception of the Contech, which had 50 ml. An additional treatment consisted of the Contech with the different brand of apple cider vinegar. The replicate orchards (all cherry) had a history of high trap catches in 2010. Traps were deployed in mid-July when captures began to increase across the region, and contents were counted and bait replaced weekly.

The Haviland trap had significantly higher trap captures than the other traps; the clear deli cup and the Van Steenwyk trap had the next highest capture (Fig. 4). The modified Haviland, red cup, and Contech (with Western Family Apple Cider Vinegar) had the lowest captures, with the exception of the Contech with Heinz apple cider vinegar, which caught the fewest.

Haviland trap mesh top, cover

Modified Haviland trap (10 holes in sides, no cover)

Van Steenwyk trap, 1 qt ice cream, mesh top, cover

Deli cup (1 qt, 10 holes in sides)

Red cup (1 qt, 10 holes in sides)

Contech (2 holes in sides)

Fig. 3. Traps used in standardized trap comparison, eastern Washington, 2011.

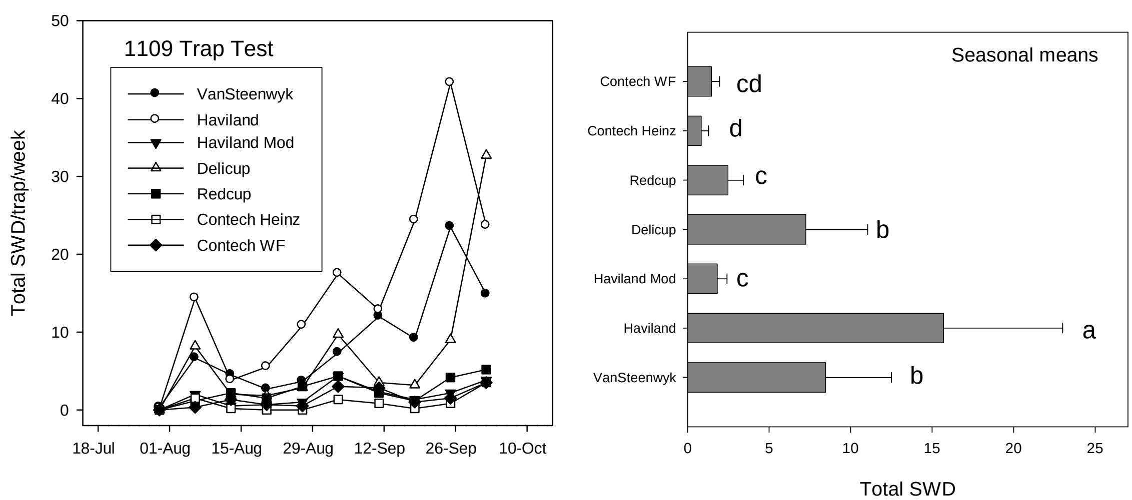

Fig. 4. Trap catches (weekly and seasonal means) of SWD in six trap types, 2011.

Bait Comparison. A comparison of bait and trap type/bait combinations was tested in eight replicate orchards. The highest total captures were made in the deli cup/ACV trap, followed by the Contech/Superbait and Contech/ACV, which is consistent with the 2010 trapping program. The yeast bait was the least attractive of the three baits tested (Fig. 5).

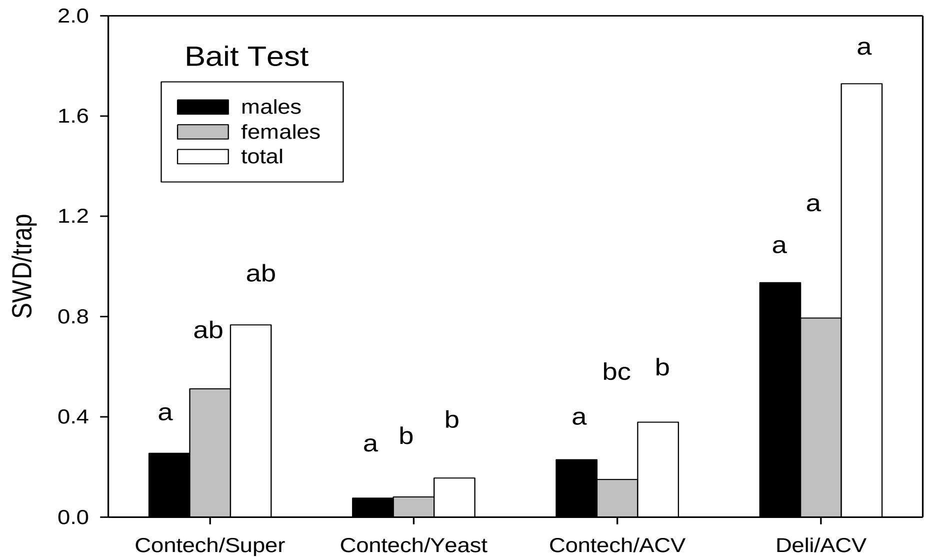

Fig. 5. Three baits in Contech traps compared ACV in a deli cup trap.

Scentry Lure Test. A series of dry lures from Scentry was tested in July-October. The lures consisted of dry plugs or fibers impregnated with various fruit odors. The compounds tested included damascenone (plug); apple cider vinegar (fiber); cis-2-Penten-1-ol (plug); 2-(diethylamino)ethanol (plug), red raspberry vinegar (fiber), and 2-methylbutyic acid (plug). The lures were placed in a small plastic basket with large holes for scent diffusion, and suspended above 100 ml water plus surfactant in a 1 qt clear plastic glass jar with a screw top. The lures were compared to 100 ml liquid apple cider vinegar in the same size container. All traps had 10 3/16th in holes drilled around the upper edge for scent diffusion; the holes were about at the same level as the lure basket.

None of the compounds tested provided significant attraction of SWD, or for that matter, other insects (Fig. 6). Only liquid apple cider vinegar caught appreciable numbers of SWD. After it became

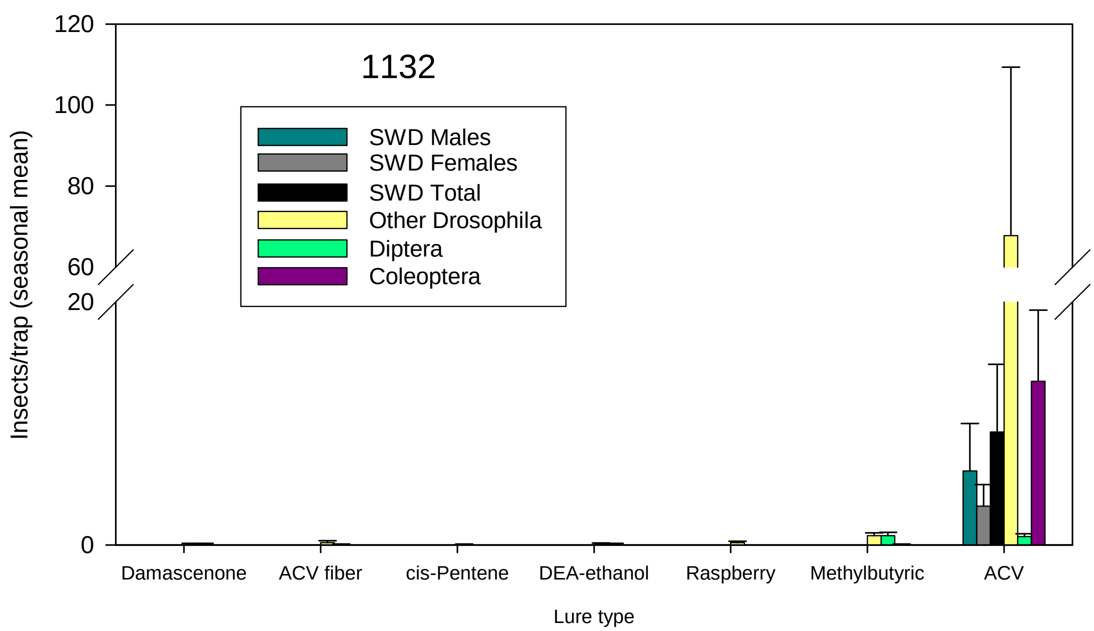

Fig. 6. Capture of SWD and other trap contaminants with various fruit-scented dry lures in comparison with apple cider vinegar bait, 2011.

apparent that no catch was occurring in the dry lure traps, sticky cards were added to the trap to ensure that lack of capture was not due to the fluid used (water vs. ACV). However, even with the addition of sticky cards, there was no capture of SWD with the dry lures.

Cherry Fruit Susceptibility. These data are still being analyzed, however, preliminary analysis indicates that in laboratory bioassays, both ripe and unripe fruit were susceptible to attack by SWD in no-choice tests. Fruit were not attacked until after commercial harvest time in field tests, although this was likely a result of the method of exposure (sleeve cages) rather than a true reflection of susceptibility. A full report will be posted on the SWD website when it becomes available.

Pesticide Efficacy. Twenty-one bioassays of varying types were performed with SWD during 2011 (tests still ongoing); selected tests are shown in the following tables. Early bioassays used a plastic portion cup provisioned with honey/water and drosophila medium; later bioassays used cherry leaf-lined 16 oz deli cups, similarly provisioned. A variation was the addition of fruit to the bioassay arena, which allowed us to evaluate fruit damage (oviposition punctures) as well as mortality. These bioassays provide an initial screening of some toxicants, and more detailed rate effects on those known to be effective. Early bioassays clearly indicated that female SWD were more difficult to kill than males; since females are also the damaging stage, only females were used in later tests.

Among the new materials, tolfenpyrad shows promise as a topical material for SWD (Table 1). An organically approved compound, EF300 (a mixture of ground herbs and spices) had no effect on mortality (Table 2). Pyganic 1.4EC caused a moderate amount of mortality at the highest label rate of 64 fl oz, but none of the lower rates tested were significantly different than the check. Interestingly, Pyganic 5EC (Table 2) had even poorer activity, although it was tested at the maximum rate per acre and the highest concentration allowed by the label.

Table 1. Mortality of male and female SWD with tolfenpyrad and Delegate, 2011

1101-02, 48 h mortality, portion cup, contact+oral					
Treatment	Rate/100 gal	Females % Mortality		Males % Mortality	
Tolfenpyrad 15SC	27 fl oz	73.84	b	90.00	b
Delegate 25WG	7 oz	100.00	a	100.00	a
Check	-----	0.00	c	4.00	c
1101-03, 48 h mortality, portion cup, contact only					
Treatment	Rate/100 gal	Females % Mortality		Males % Mortality	
Tolfenpyrad 15SC	27 fl oz	34.00	b	84.00	b
Delegate 25WG	7 oz	100.00	a	100.00	a
Check	-----	1.00	c	16.00	c

Table 2. Mortality of male and female SWD with EF-300 and Pyganic, 2011

1101-11, 48 h mortality, contact, portion cup,					
Treatment	Rate (% v/v)	Female % Mortality		Male % Mortality	
EF300 1.25%	1.25%	17	a	14	a
EF300 0.75%	0.75%	11	a	3	a
Check	---	13	a	6	a

1101-12, contact, 48 h mortality, females only			
Treatment	Rate/100 gal	Female % Mortality	
PyGanic 1.4EC	64 fl oz	51	a
PyGanic 1.4EC	32 fl oz	16	b
PyGanic 1.4EC	16 fl oz	13	b
Check		1	b
1101-15, contact, 48 h mortality, females only			
Treatment	Rate/volume	Female % Mortality	
PyGanic 5EC	18 fl oz/20 gal	29.26	a
PyGanic 5EC	18 fl oz/50 gal	9.00	ab
PyGanic 5EC	18 fl oz/100 gal	0.00	c
Check		4.00	bc

Entrust showed a significant rate effect in two separate bioassays (Table 3). The two higher rates (>1.8 oz/100 gal) had high (97-100%) levels of mortality, but the lower rate (1-1.25 oz/100 gal) caused significantly less mortality (about 70% for females).

Table 3. Mortality of male and female SWD with Entrust, 2011

1101-09, 48 h mortality, contact, portion cup					
Treatment	Rate/100 gal	Female % Mortality		Male % Mortality	
Entrust 80W	3 oz	100	a	100	a
Entrust 80W	2 oz	100	a	100	a
Entrust 80W	1 oz	69	b	90	b
Check	-----	2	c	1	c
1101-10, 48 h mortality, contact, portion cup					
Treatment	Rate/100 gal	Female % Mortality		Male % Mortality	
Entrust 80W	2.25 oz	100	a	100	a
Entrust 80W	1.80 oz	97	a	100	a
Entrust 80W	1.25 oz	71	b	89	b
Check	-----	0	c	0	c

Fruit dip bioassays provided further information on whether materials could, in addition to killing adults, protect fruit from damage (Table 4). Either all or half of cherry fruits were dipped in solutions of Entrust (2.25 or 3 oz) or Provado (8 fl oz). Entrust at 3 oz provided the highest level of fruit protection (complete suppression of oviposition), regardless of whether whole or half fruits were treated. The 2.25 oz rate of Entrust provided significant protection, but some oviposition occurred. Provado suppressed fruit damage, although when only half the fruit was treated, the damage was not different than the check.

Table 4. Oviposition damage and mortality following exposure to treated cherries, 2011

1101-07, 48 h oviposition, cherries whole or half fruit dipped				
Treatment	Rate/100 gal	Fruit part treated	Ovip/fruit	
Entrust 80W	2.25 oz	whole	2.80	bc
Entrust 80W	2.25 oz	half	0.40	bc
Entrust 80W	3.0 oz	whole	0.00	c
Entrust 80W	3.0 oz	half	0.00	c
Provado 1.6F	8 fl oz	whole	0.60	bc
Provado 1.6F	8 fl oz	half	4.20	ab
Check	-----		11.40	a

1101-05, 24 h mortality, cherries, whole or half fruit dipped				
Treatment	Rate/100 gal	Fruit part treated	% Mortality	
Delegate 25WG	7 oz	whole	96	a
Delegate 25WG	7 oz	half	96	a
Tolfenpyrad 15SC	27 fl oz	whole	44	b
Tolfenpyrad 15SC	27 fl oz	half	12	c
Check	-----	---	8	c

Delegate caused high levels of mortality when either whole or half fruit were dipped; tolfenpyrad, however, caused only moderate amounts of mortality when whole fruit were treated, and nonsignificant levels when only half fruits were treated (Table 4).

Table 5. SWD mortality exposed to GF-120, 2011

1101-06, 48 h mortality, portion cup			
Treatment	Dilution	% Mortality	
GF-120 1:1	(undiluted)	100	a
GF-120 1:5	1:5	100	a
Check	-----	20	b

When adults were exposed to droplets of GF-10, all dilutions tested caused 100% mortality (Table 5). An additional series of bioassays tested (Fig. 7) various combinations of baits and toxicants, using the same ppm of spinosad as GF-120. All combinations tested provided similar levels of mortality (Fig. 7) to GF-120; the addition of the bait to the toxicant always improved mortality over the toxicant alone. This provides preliminary evidence that other baits may be used to enhance control of SWD. It should be noted that tests in bioassay arenas are essentially no-choice tests, and that results cannot be extrapolated to field situations without additional testing.

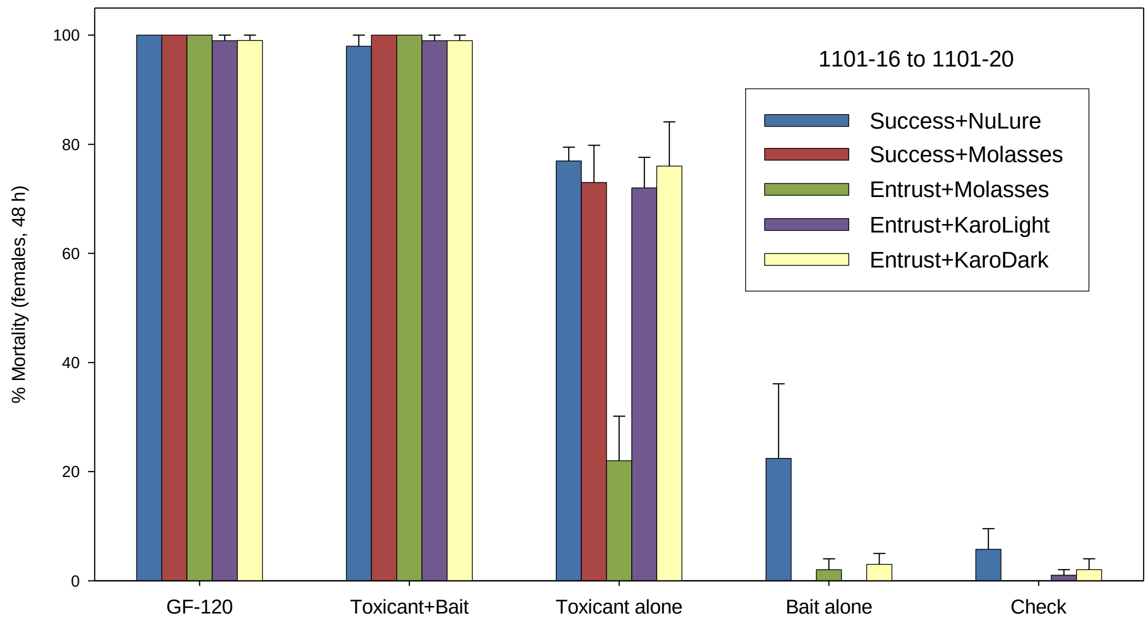

Fig. 7. Mortality of SWD exposed to droplets of bait+toxicant (spinosad), 2011.

A further extension of this concept was tested using the same bioassay arena, but adding three cherry fruits to each and evaluating both mortality and oviposition (fruit protection) (Table 6). All treatments containing a toxicant had high levels of mortality in both males and females, and decreased the oviposition damage to the fruit. However, only the Entrust+NuLure treatment significantly reduced the number of emerged adults in relation to the check.

Table 6. Mortality, oviposition, and adult emergence of SWD exposed to bait+toxicant droplets, 2011

Treatment	n	% Mortality (Males)	x	% Mortality (Females)	x	Total oviposition punctures/ 3 fruit		Emerged adults	x
GF-120	5	100	a	100	a	31.80	b	14.60	ab
Entrust+NuLure	5	90	a	96	a	12.20	b	10.40	b
Entrust alone	5	94	a	96	a	49.80	b	25.80	a
NuLure alone	5	10	b	2	b	131.40	a	38.40	a
Check	5	0	b	4	b	137.40	a	39.20	a

[x]Data transformed arcsine(sqrt(x/100) (percentage data) or log(x+0.5) (continuous).

GF-120 Field Trial. An unreplicated large block trial was performed to test the efficacy of GF-120 against SWD. A 0.4 acre research cherry orchard was divided into three plots of 3-4 rows each. Treatments consisted of 4 weekly applications of 1) GF-120, applied with an ATV-mounted sprayer, 2) Entrust applied with a mist blower, or 3) untreated check. Fruits were harvested on three dates to determine infestation (Fig. 8).

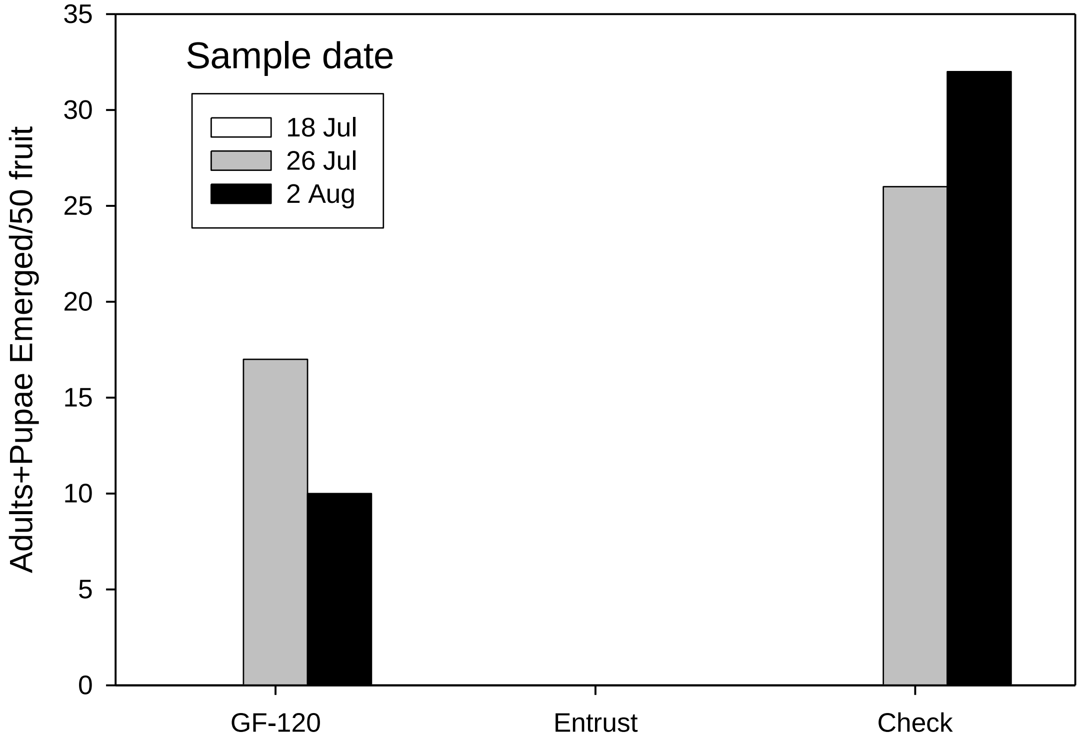

Fig. 8. Unreplicated field trial of GF-120, 2011.

Entrust provided excellent control of SWD infestation, with no fruit damage evident (Fig. 8). GF-120 appeared to suppress infestation levels relative to the untreated check. While GF-120 may not provide stand-alone control of SWD, this technique merits further evaluation in organic orchards as a supplementary measure, especially within the preharvest interval for Entrust, or when airblast equipment can no longer go through the orchard.

Replicated Field Trial. A replicated field trial was performed to test various combinations and timings of materials for control of GF-120. The test was conducted at the Sunrise orchard near Rock Island, WA. Plot size was 3 rows x 4 trees, with 6 treatments replicated 4 times.

No natural infestation was evident (likely due the late season), so residues on fruit and leaves were challenged with lab-reared flies to determine the efficacy of the residues (Fig. 9). All treatments except Delegate provided excellent prevention of oviposition damage, which allowed a moderate level of oviposition. All treatments caused high levels of mortality (data not shown).

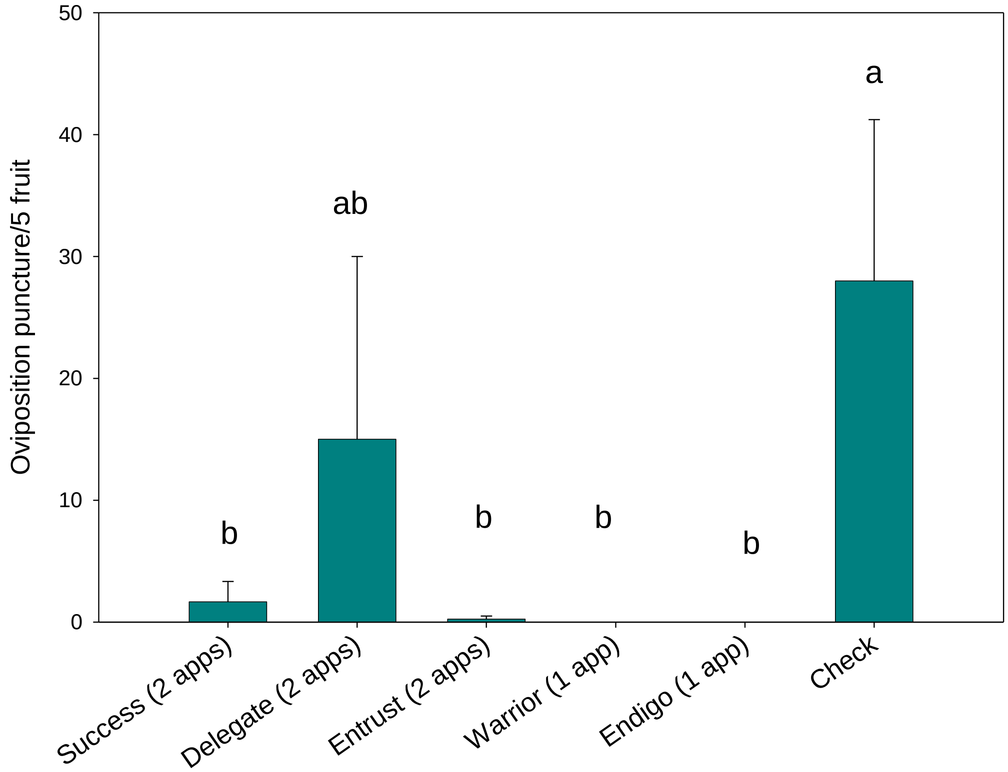

Fig. 9. Fruit protection from field treatment of ‘Sweetheart’ cherries treated with various pesticide regimes, 2011.

Executive Summary
The eastern Washington trapping program and website/email alert system provided consultants and growers with reliable and accessible information on trap catch in the various fruit-growing regions in 2011. This information served as a guide to begin crop protection measures. The populations in 2011 were considerably lower than in the previous year; some orchards were harvested before the first trap catch occurred in that region. However, significant questions still remain on the interpretation of trap catch, and specifically its value as a predictor of crop risk. Part of the question hinges on the type of trap and lure used; information from a trap type test (all using apple cider vinegar) indicates that more SWD are caught in a trap with a large bait surface and diffusion area. However, this trap type requires a shield to keep rain and irrigation from diluting the contents, and is more difficult to manufacture and maintain than a closed-top style. Alternative baits (wine- and yeast-based) are alternatives to ACV; wine baits appear to improve capture over SWD, while yeast baits had lower capture. Both alternatives are more labor intensive (in the sense they currently must be custom mixed), and more expensive to produce. Dry lures present a low-maintenance alternative to wet bait traps, but to date, none of the lures tested were attractive to SWD.

Pesticide choices are still being refined for SWD. Initial work indicated spinosyns, organophosphates, and pyrethroids as materials with efficacy against SWD. My work has helped refine rates for some of the more important materials, as well as screen new compounds for efficacy. I have given emphasis to organically approved materials, with the understanding that control in organic orchards is a greater challenge than in conventional orchards.