Progress Report – Submitted Feb 2, 2015

Second Quarterly Report

Spotted wing drosophila in Virginia vineyards: Distribution, varietal susceptibility, monitoring and control

D. G. Pfeiffer, M. E. Shrader and C. A. Laub

Department of Entomology, Virginia Tech, Blacksburg, VA 24061

Varietal Oviposition Preference and Survivorship Trial

In the late summer and fall of 2012 several grape growers were experiencing problems with *Drosophila suzukii*, also known as the spotted wing drosophila (SWD), infesting their thin-skinned red grapes. Several theories evolved as to why the SWD would seemingly be more attracted to these varieties. Suggestions of preference ranged from the skin thickness allowing for easier oviposition by the fly to sugar levels being higher in the red varieties. Another factor might be that the red grape varieties were the only grapes left in the field when SWD population levels became economically damaging. In order to ascertain if the SWD has an affinity for red thin-skinned grapes a varietal preference test including both choice and non-choice experiments was conducted in the late summer / fall of 2013. This data showed that there was no specific grape variety preferred for oviposition among the six grape varieties tested. This was despite all the grapes tested having significantly different skin thickness, penetration force, and degrees Brix at the time of testing. It was assumed that the testing arena was not conducive to oviposition preference testing, so a new methodology was developed for the 2014 testing to see if a varietal preference could be ascertained.

Materials and Methods

The varietal preference testing included six different varieties of wine grapes. The varieties selected included; Petit Manseng, Petit Verdot, Vidal, Viognier, Cabernet Franc, and Pinotage. Field-collected clusters of each variety came from a single vineyard located in the Piedmont region (Orange County) of Virginia. Testing was conducted weekly for 4 weeks starting just after véraison. Clusters were collected, ice-cooled and transported back to Blacksburg for laboratory testing. Testing began within 24 hours after grape clusters were removed from the field. Testing for the varietal preferences consisted of a constant mass of 9.5 – 10.5 grams of grapes for each of the six varieties. Individual grapes were cut from the cluster using scissors cut the stem in order to avoid exposing injured flesh; if grapes were picked off the cluster the area where the pedicle attached would be a prime oviposition spot. Grapes were weighed individually so an approximate number of grapes per sample could be calculated in case grape size was a factor in SWD infestation. Other factors to be evaluated were, skin color, skin-thickness, penetration force, and degrees Brix at the time of testing. Fifteen male and female

SWD flies of breeding age were placed into the 12 oz plastic cups with the grapes. Fruit were exposed to flies for a 48-hour period and removed. Grapes were kept in plastic rearing cups and observed for a 21-day period. Emerging flies were collected, counted and identified. Data were analyzed using and ANOVA and Tukey-Kramer test to separate the means.

Results

An ANOVA was run to look at all aspects of the grapes tested and the testing was blocked by date which was significant for all three parameters that were analyzed. Grape varieties had significantly different penetration forces with Viognier being the easiest to penetrate requiring 11.5 centinewtons to pierce the skin. The two hardest varieties to penetrate were Vidal and Petit Mansang, requiring 18 and 17 centinewtons to pierce the skin, respectively. The thickest skinned varieties were Vidal, Cabernet Franc and Petit Mansang, with skin thicknesses measured at 0.13, 0.126 and 0.123 mm respectively. The variety that had the most eggs laid with a mean of 10.1 eggs per replicate was Viognier, while the least number of eggs were laid on the Vidal grapes. However, the grape variety that had the highest survivorship for eggs laid and emerging adults was Vidal with the highest mortality seen in Petit Mansang. These results need to be looked at more closely taking into account degrees Brix to see if a risk ranking scale can be determined for each grape variety so that growers can scrutinize the higher risk varieties where they are close to harvest.

Discussion

The grape varieties that had the least penetration force also had the thinnest skins, which were Viognier, Petit Verdot and Pinotage. However, the eggs laid on these varieties had a high mortality and did not result in many SWD adults emerging. While the Viognier had numerically higher eggs laid it was only significantly different from Vidal, which had the fewest eggs laid. It appears that all varieties of grapes are still at risk for SWD oviposition with no clear preference being seen in this trial. This is similar to last year's (2013) results when no preference was seen in multiple choice trials in mesh cages. All grapes need to be monitored for SWD population explosions close to harvest. Perhaps growing thicker-skinned varieties that mature early would be worth evaluating in the future to help prevent losses from SWD.

<u>**Trap Trials**</u>

There have been several attempts to find an SWD attractant that would allow growers to quantify the SWD populations in the field based on trap counts. Right now the standard apple cider vinegar trap (ACV) is a qualitative tool. Several other baits such as yeast, wine + ACV, acetic acid and ethanol have been evaluated by Cha et al. (2013) and Landolt et al. (2012) with limited success in the field. However, these chemicals are all fermentation volatiles. The SWD is attracted to ripening fruit, not necessarily to overripe or rotting fruit the use of fruit volatiles, especially those from ripe fruit would seem to be a better choice for use as bait. That is why we selected the scent of a plum to be used as an attractant in vineyards. This plum attractant should be more desirable than the fermentation products normally used.

Materials and Methods

All trapping data were collected in two vineyards in the Piedmont region of Virginia. Since Petit Verdot grapes had been a severely infested variety the previous season the traps were placed in this variety alone. Traps were checked weekly for 4 weeks. Trapping pressure was not high at either location, but the second site had fewer flies captured compared to site 1. Traps consisted of a plastic deli cup with eight 0.6 cm holes around the top of the cup. The baits selected for this trial included the standard ACV, ACV + Merlot (60/40 mix), yeast, two plum essence sachet from Alpha Scents and a blank consisting of low-tox antifreeze. The yeast traps were changed weekly so a fungal mat would not hinder fly capture. The plum traps had the two plum sachet changed biweekly and used a trapping liquid of low-tox antifreeze. The ACV and ACV/merlot mix was also changed biweekly. All trapping liquids had a drop of liquid dish soap added as a surfactant that would break surface tension allowing for optimal trapping. Traps were hung in the canopy of the grape vines and checked weekly for flies. The traps were randomized in the field weekly and a total of four replicates were evaluated. All flies were collected, counted and identified in the lab in Blacksburg.

Results

Data were analyzed using and ANOVA and a Tukey-Kramer test was used to separate the means. There seems to be a significant difference in the total number of flies captured between the two sights, so data was also blocked by location and date. Blocking by location was statistically significant ($P < 0.0001$, df = 1, $F = 26.7509$), however the date of trapping was not significant for either location. Therefore data were analyzed separately by site as well as combined. There was statistical evidence that the ACV + Merlot mixture attracted significantly more SWD when both male and female SWD were combined at site 1 ($P < 0.0001$, df= 4, $F= 14.8227$). When looked at by sex from site 1 the females were more attracted to the ACV + Merlot mix. ACV and plum were equally attractive, but not as attractive as the ACV + Merlot mix. With an average of 63, 25, and 23 female flies being captured per trap respectively ($P< 0.0001$, df= 4, $F= 21.833$). The males were attracted more to the ACV + Merlot mix with an average of 115 males per trap ($P< 0.0001$, df= 4, $F= 11.3332$). There was also a significantly greater number of other flies attracted to the ACV + Merlot mixture and ACV with an average of 95 and 49 other drosophila captured respectively per trap ($P< 0.0001$, df= 4, $F= 20.5137$). This extra by-catch was a hindrance when trying to count, sex and separate all the flies in the traps. This also shows that the wine mixture was not specific to attracting SWD. The trap trial also showed that yeast was the least preferred bait for the female SWD with all other baits being more attractive. The same trend was seen at site 2 with ACV and Merlot being statistically significantly more attractive than any other bait for both sexes.

Discussion

These results were similar to those of Cha et al. (2012) where they showed the ACV + Merlot mixture was significantly more attractive to SWD than all other fermentative volatiles they tested. The female flies are the economically important sex and it is more important to get accurate trap numbers for them and be able to correlate the trap numbers to the populations in the field. The yeast trap will no longer be tested due to the low attractiveness and difficult data collection from this trap. The ACV + Merlot mixture will be the new standard for trap counts in my research.

Alternative host plant investigation

The SWD has several cultivated host plants including caneberries, strawberries, blueberries and grapes. The SWD also uses non-cultivated crops when these preferred cultivated crops are not available. Some non-cultivated crops include wild caneberries, poke weed, wild rose hips and several other fruiting plants. Although some of the alternative host plants are known, there is not one that can be identified as the prime source for SWD in the spring and early summer. If we could identify all essential host plants needed for SWD population build up in the spring we could then remove them from the landscape. Furthermore, host plants that are identified throughout the growing season should also be removed. This would be especially important when cultivated crops are sprayed, these alternative plants may act as an unsprayed harborage for the SWD. Once sprays have dissipated flies could then move back into the cultivated crop. This removal of essential host plants from the immediate areas surrounding cultivated crops could possibly keep SWD populations lower for longer in these areas. In order to ascertain what wild host plants the SWD are using we decided to collect plant samples from four geographically distinct areas.

Materials and Methods

The four distinct vineyards where samples were collected can be described as: 1. Small vineyard located in a forest clearing surrounded by woods. 2. Large vineyard near apple production and a wooded boarder with two grass boarders. 3. Small vineyard with wooded border and a grass pasture with cattle. 4. Large vineyard with soybean fields, some grassland and patchy wooded areas. Biweekly plant samples were collected from each of these locations. Plant samples were collected, labeled and their collection site marked with a handheld GPS device. Plant samples were then taken back to the lab at Blacksburg where they were identified and monitored for 14 days. This period of time should be long enough for larvae, pupae or adults to emerge from the plant samples. Any flies that emerged were collected, identified and placed in alcohol vials. Plants that had flies emerge were noted and kept in a log book and any seasonal plant preferences were noted.

Results

Over 590 plant samples were collected from June to mid-October when frost occurred. There were 30 plant families represented in these samples. Any plant that had a nectar source or fruiting body was collected. There were only three families that were identified as being host plants. These were Rosaceae, Phytolaccaceae, and Caprifoliaceae. Specific plants that had adult flies emerge are wild blackberries, mock strawberries, pokeweed, and tatarian honeysuckle respectively. For seasonal patterns of SWD preference the tartarian honeysuckle, pokeweed and blackberries had SWD emerge early in the growing season in June and July. Once grapes reached véraison no plant samples yielded adult SWD. However, once grape harvest began in October, SWD were seen again in the alternative host plants. Pokeweed and wild cherry trees yielded several SWD positive samples after grapes were removed from the field. Adult SWD were then found emerging from mock strawberry samples after grapes were removed from the field.

Table 3. Plant families and common names of foliage that were sampled from June – October 2014. *Plant samples that had adult SWD emerge from foliar samples.

Plant Family	**Common Names of plants sampled**
Rosaceae*	wild rose, cultivated rose, mock strawberry, bird cherry tree, wild blackberries
Solanaceae	Jimson weed, horse nettle, black nightshade
Phytolaccaceae*	poke weed
Convolvulaceae	ivy morning glory, hedge bindweed
Polygonaceae	lady's thumb, *Polygonum*
Anacardiaceae	poison ivy, sumac
Sestonia Cannabaceae	hemp
Malvaceae	velvet leaf, Abutilon
Brassicaceae	garden yalla
Asteraceae	ragweed, tall goldenrod, slender aster, wild daisy, bull thistle (*Cirsium*), cocklebur, purple cudweed
Caprifoliaceae*	Japanese honey suckle, Indian currant, elderberry, tartarian honeysuckle
Passifloraceae	passion flower

Moraceae	mulberry
Lamiaceae	Catnip, beautyberry
Ericaceae	blueberry
Cupressaceae	Juniper
Vitaceae	wild grape
Amaranthaceae	slender amaranth
Euphorbiaceae	Virginia copperleaf
Fabaceae	hairy vetch
Oxalidaceae	yellow wood sorrel
Scrophulariaceae	common mullein
Plantaginaceae	American speedwell
Euphorbiaceae	toothed spurge

Discussion

The first adult emerged 15 July of this year from tartarian honey suckle, showing again this is a primary alternative host of SWD. A new host was found in one location where wild cherry trees were a source for SWD late in the season when grapes had been harvested from the fields. All of the locations had wild blackberries, pokeweed and mock strawberries while only one location had the tatarian honeysuckle. SWD adults emerged from pokeweed and wild blackberry samples at all locations. The SWD emerged from the tatarian honeysuckle at site 4 only and the SWD. Pokeweed, wild blackberries and tatarian honeysuckle are conspicuous and can be easily bush hogged when they appear in the landscape. All aspects of IPM should be considered when attempting to control a pest in any cropping system and host plant removal should be viewed as a potential option for early season control of SWD in Virginia vineyards. Field populations of SWD were also observed, but were at low levels and were not accounted for when analyzing the data. All data was analyzed using an ANOVA.

Interactions between Spotted wing drosophila and African fig fly

The insect pest ecology within Virginia vineyards has changed dramatically over the past decade with the introduction of several new invasive species. The latest introductions have been SWD, and the African fig fly (AFF), *Zaprionus indianus*. While SWD is a direct pest of wine grapes, impacting production by ovipositing into individual grapes, AFF is a secondary pest which uses SWD oviposition wounds as well as cracked grapes as oviposition sites. Both fly species are capable of introducing pathogenic infections such as yeasts into the grape clusters. Depending on the larval infestation of the grapes, and the resulting sour rot, the whole cluster may be unsuitable for use in wine production. An observation by a Piedmont wine grower in

2012 estimated they lost 80% of a grape variety due to fly infestation and sour rot. The grower had an infestation of SWD, however the majority of flies in the field and adult flies reared in the lab from infested grape clusters were identified as AFF. The objective of this study was to try and understand the interactions of AFF larvae on SWD larvae within the vineyard.

The relationship of fly larvae within a food source has been reported to be competitive, thus leading to the increased mortality, decreased growth and reduced fecundity of the competing individuals based upon density (Bakker 1961). The degree of interspecific competition was measured by larval and pupal mortality, pupal volume, developmental time and the number of eggs laid by emerging SWD females.

Materials and Methods

Commercial Media Study. Larval densities tested (SWD:AFF); 2:2 and 4:4. Controls for each species were also tested with four and eight eggs per media cube. A total of 15 reps for both the interspecific competition study and controls was conducted. Eggs less than 24 hrs old of SWD and AFF were collected and placed on a 0.38g molasses media cube. Cubes were then placed into a 20 ml glass tube and capped with a cotton ball. Tubes were held in a growth chamber at 12:12 L/D at 23° C until pupation.

Wine Grape Study. Larval densities on a wine grape (SWD:AFF); 4:4 and 8:8 on a single wine grape. Each grape weighed approximately 1.5g with an average degrees brix of 22. Controls for each were 8 and 16 larva per grape. Ten reps for both the interspecific competition and controls were conducted. L1 larva instead of eggs and were placed onto a single Petit Verdot grape. Grapes were then placed into a 20 ml glass tube and capped with a cotton ball. Tubes were held in a growth chamber at 12:12 L/D at 23° C until pupation.

Competition Evaluation. Larval and pupal mortality were observed and recorded during both studies. Pupae were removed from the media blocks and grapes and measured (length and width) to determine pupal volume* (Takahashi and Kimura 2005). Each pupa was placed into a 15 ml glass specimen tube and plugged with a cotton ball until emergence. Developmental time from egg to adult was recorded. The sex of each fly was determined and fitness was evaluated based on the lifetime egg production of any females that emerged.

$$*V = \frac{4}{3}\pi\left(\frac{w}{2}\right)^2\left(\frac{l}{2}\right)$$

Results

Commercial Media Study. There was no significant interspecific interaction between SWD and AFF for pupal volume at the 2:2 and 4:4 densities when compared to the corresponding controls (Table 1). The mean number of number of eggs laid by females was also not affected. However, there was a significantly **longer** developmental time as well as an increase in larval mortality at the 4:4 density when compared to the control **(with an equivalent number of SWD neighbors)** (df = 3, F = 14.5, P < 0.0001 (Table 1).

Wine Grape Study. Both larval and pupal mortality of SWD was too high to determine any statistically significant interspecific interactions (Table 2). Mortality of AFF was significant; however emergence from grapes was higher numerically than that of SWD. No female SWD survived long enough to collect any oviposition data. AFF pupal volume did not decrease due to density.

Discussion

While the interactions of AFF larvae at the 4:4 density on the commercial media showed an increase in developmental days as well as an increase in larval mortality the resulting female SWD did not show a decrease in pupal volume. They also did not show a decrease in fecundity at the densities tested. Since pupal volume is directly correlated to the reproductive potential of female flies the interspecific competition study on media needs to be repeated until the egg/larval density effects pupal volume. The increase in developmental days may impact the number of generations a year in vineyards. This may be more important around harvest when populations explode. Delaying emergence by a couple days may give growers a larger window to harvest the grapes. The mortality for SWD on grapes was significant with only 2-5% emerging as adults for the interspecific competition as well as for the controls. Pupal volume for both species decreased overall when compared to the flies reared on media. AFF survivorship rate **was** around 20%, which correlates with field and laboratory findings in grapes. This experiment needs to be repeated at lower densities to give a more accurate assessment of AFF larval competition with SWD. The high mortality of both fly species may be due in part to the lack of nutrition available from the grapes. Even though grapes (~1.5g) weighed significantly more than the media cube (0.38g) the seed of the grape instead of flesh comprised most of the mass, which is not utilized as nutrition for fly development. Further testing involving an uneven density of egg/larvae for AFF and SWD interactions might also shine some insight into the interspecific competition of AFF and SWD. An increase of SWD mortality by AFF in the grapes maybe beneficial to growers by limiting the SWD populations in the field. If AFF follows every SWD oviposition wound and 80% of what emerges is AFF, which cannot oviposit into intact grapes, then the SWD populations should decrease. Therefore the amount of damaged clusters should also decrease or remain the same based upon the number of SWD females that emerge.

Table 1. Table 1. Summary of interspecific density competition study between D. suzukii and Z. indianus on 0.38g commercial media at two different densities. Data only representative of SWD.

Substrate	Egg Density on Substrate	Mean Pupal Volume (mm³)	Mean Developmental Time (days)	Mean Eggs Laid in Lifetime	Larval Mortality (%)	Pupal Mortality (%)
Media	2:2(SWD: AFF)	3.8 ± 0.12 f 3.3 ± 0.08 m	11.1 ± 0.08 f 11.0 ± 0.11 m	156 ± 26.1	23.3	17
	4 SWD Control	4.0 ± 0.11 f 3.5 ± 0.09 m	11.0 ± 0.0 f 10.7 ± 0.11 m	199.4 ± 30.7	31	0
	4:4(SWD: AFF)	4.1± 0.13 f 3.6± 0.1 m	11.2 ± 0.1 f* 11.1 ± 0.13 m*	206.8 ± 31.2	35*	25.6
	8 SWD Control	3.9± 0.1 f 3.6± 0.1 m	10.5 ± 0.13 f 10.2 ± 0.17 m	181.0 ± 34.0	15	24.5

Table 2. Summary of interspecific density competition study between *D. suzukii* and *Z. indianus* on a single Petit Verdot grape.

Substrate	Larval Density on Substrate	Fly Species	Mean Pupal Volume(mm³)	Mean Developmental Time (days)	Mean Eggs Laid in Lifetime	Larval Mortality (%)	Pupal Mortality (%)	Total Mortality (%)
Petit Verdot Grape	4:4(SWD: AFF)	SWD	2.9 Sexes combined	N/A	N/A	97.5	100	100
		AFF	2.9 ± 0.1	16 ± 1.5	N/A	80.0	12.5	82.5
	8 SWD Control	SWD	2.9 Sexes combined	11 (2 female, 1 male)	N/A	87.5	60	95
	8:8(SWD: AFF)	SWD	2.6 Sexes combined	11 (1 female)	N/A	95	75	98.8
		AFF	3.01 ± 0.19	14.4 ± 0.6	N/A	70	37.7	81.3
	16 SWD Control	SWD	2.9 Sexes combined	14 (1 male)	N/A	97	80	99.4

References Cited

Bakker, K. 1961. An analysis of factors which determine success in competition for food among larvae of *Drosophila melanogaster*. Arch. Neerl. Zool. 14: 200-281.

Takahashi, K. H. and Kimura, M. T. 2005. Intraspecific and interspecific larval interaction in *Drosophila* assessed by integrated fitness measure. Oikos. 111: 574-582.

Acknowledgements

I would like to thank my advisors and summer field technician Cory for helping me gather and analyze this data. This research was supported in part by the Virginia Wine Board.

Control recommendations

A chemical control trial was carried out in a commercial vineyard in Amherst County. Emphasis was placed on cyantraniliprole (Exirel; DPX-HGW). This material was recently registered for spotted wing drosophila on cherry and blueberry; grape and raspberry are not on the Exirel label. Since this material is effective against SWD, we would like to strengthen the case for label expansion. Since this insecticide is expensive, our trial explored the feasibility of lower rates combined with addition of a feeding bait to increase exposure to residues.

Treatment protocol:

All treatments were applied as foliar sprays by hand using a CO_2 powered backpack sprayer and single wand equipped with a 8008VS stainless steel spray tip and calibrated to deliver 80 gpa at 40 psi. Treatments were applied on 5 dates (13, 19, and 27 August, and 2 and 9 September); plots were sampled 6, 8, 6, 7, and 3 days after each treatment date, respectively.

Treatment List:

Trt. No	Treatment	Rate fml per acre
1	DPX-HGW-86 10SE	8.0
	Induce 90 SL	0.8
2	DPX-HGW-86 10SE	4.0
	Induce 90 SL	0.8
	Monterey Bait	32.0
3	DPX-HGW-86 10SE	8.0
	Induce 90 SL	0.8
	Monterey Bait	32.0
4	Control	--

Spray dates, conditions, and sample dates

Spray date	Time and Conditions at Spraying	Post Spray Sample date (DAT)
13-Aug	6-6:30 pm. Clear, slight breeze, 75-80 F	19-Aug (6 DAT)
19-Aug	5-6 pm Cloudy. Slight breeze, 75-80 F	27-Aug (8 DAT)
27-Aug	6-7 pm. Clear, calm, 75-80 F	2-Sep (6 DAT)
2-Sep	4-5 pm. Clear, calm, 85-90 F	9-Sep (7 DAT)
9-Sep	4-5 pm. Clear, calm, 85-90 F	12-Sep (3 DAT)

Sampling protocol:

In a pre-spray sample on 13 August, 3 clusters of grapes were collected from the vines to be treated. Clusters were kept at ambient temperature for 36 hours (until 15 August). All grapes were then dissected and inspected for SWD injury and / or presence. Zero SWD injury or larvae were detected in the pre-spray sample.

For all the other (post treatment) sample dates, one cluster per plot was harvested and kept in zippered plastic bags at ambient temperature for approximately 48 hours. All grapes were then dissected and inspected for SWD injury and / or presence. Percent damaged berries were calculated. Sugar content was calculated from 10 berries in each treatment using a refractometer.

Results: Percent Damaged Berries

Sample Date:	8-19	8-27	9-2	9-9	9-12
DAT:	6	8	6	7	3
Avg. Brix:	16.9	18.4	20.3	21.2	21.9
Trt. No.	**Pct. Damaged Berries (+ SEM)**				
1	0.0	0.0	1.1 (0.67)	3.8 (1.49) b	6.7 (2.51) b
2	0.0	0.0	2.9 (2.80)	7.9 (2.39) b	8.8 (0.97) ab
3	0.0	0.0	0.0 (0.00	7. 9 (1.30) b	7.4 (0.76) b
4	0.0	0.0	1.9 (0.77)	18.0 (3.10) a	17.2 (3.18) a
P			0.6301	0.0054	0.0247

The treatment source of variation for percent damaged berries was highly significant ($P > 0.01$) on 9 Sep; and significant ($P > 0.05$) on 12 Sep., according to ANOVA. Statistical analysis was performed on untransformed data, and actual treatment means are shown in table. Means within a column by date followed by the same letter are not significantly different (P > 0.05; LSD).

No Phytotoxicity observed on any date for any treatment.

The higher rate of DPX-HGW-86 gave control relative to the untreated check, which had about 17% infested berries in the final sample, regardless of the addition of the Monterey bait. The low rate was intermediate, despite the addition of the bait treatment. We plan to expand examination of the bait in the coming season.

Injury was often seen in berries in the interior of the cluster. These berries would have lower or no residues from sprays. A planned project for next season is to apply Surround to several rows before berries touch in clusters, and then superimpose a chemical trial on Surround-treated and untreated vines.

Control recommendations in our Pest Management Guide have been expanded to include organophosphate (malathion), a carbamate (carbaryl), spinosyn (spinosad, spinetoram), pyrethroid and most recently kaolin clay. Discussions with Bruce Zoecklein have indicated that kaolin should pose not enological problems; vague label warnings on possible effects on harvest parameters were originally a cause of concern. We now have four mode of action classes to incorporate into a rotation for resistance management. I will be expanding testing of an additional mode of action, represented by cyazypyr (cyantraniliprole), during the winter and next season. This is expected to be efficacious, and less disruptive of biological control of other pests than the pyrethroids. I will also examine addition of sucrose to spray mixes to increase uptake by adult SWD.