SOUTHERN REGION SMALL FRUIT CONSORTIUM

A. Proposal Category: _X__Research ___Outreach

B. Proposal Status: _X_ New Proposal _ _Previously funded by SRSFC

C. Title: Use of Surround (Kaolin) against Spotted Wing Drosophila in Virginia Vineyards

D. Personnel:

Douglas G. Pfeiffer, Fruit Entomologist - dgpfeiff@vt.edu
Department of Entomology, Virginia Tech, Blacksburg, VA 24061

C. Objectives:

1) Determine efficacy of kaolin relative to synthetic and other organic insecticides against SWD in ripening grapes,
2) Determine impact of kaolin applied at berry closure in minimizing SWD infestation at harvest,
3) Determine impact of kaolin on parasitization rates in SWD in the field,
4) Determine ability of parasitoids to attach SWD in sentinel berries.

D. Justification and Description:

Spotted wing drosophila (SWD), Drosophila suzukii, was first found in Virginia in 2011, after being introduced into Florida in 2009 (Pfeiffer 2012, Pfeiffer et al. 2012). Initial thought after the earlier introduction of SWD into western states was that grape would not be a host of this pest; this may have been colored by the harsher environment for SWD in California grape-growing regions. SWD has shown itself capable of infesting grape clusters in Virginia. In the field, mature larvae were collected in ripening, apparently otherwise intact clusters (Fig. 1). In the laboratory, eggs are successfully deposited in intact grape berries (Fig. 2).


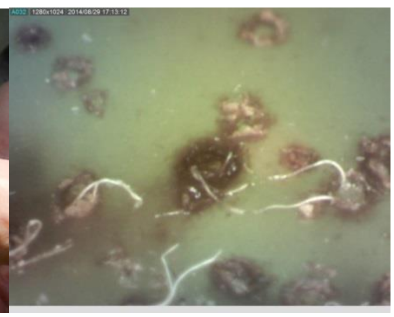

Fig. 1. Larvae of spotted wing drosophila in ripening Pinot noir berry, Bedford County Virginia.
Fig. 2. Respiratory filaments of spotted wing drosophila eggs inserted into Viognier grape.

Initial thoughts in Virginia were that thin-skinned red varieties would be at greatest risk, with white varieties being at low risk. Risk was thought to begin at veraison. Experience in our vineyards in 2013 and 2014 indicate that even white varieties are at risk; infestation would shift to the next ripening variety. However, risk seems to increase later than veraison; most egg-laying starts at around 15° Brix.

Chemical control of SWD is difficult, complicated by several factors. First, efficacy – insecticides must be toxic quickly enough to prevent oviposition. Second, resistance management – SWD poses a high risk of resistance development because of its high fecundity and high number of generations annually. Differing modes of action must be available to rotate to forestall the development of resistance. Third PHI – since SWD attacks ripening fruit, insecticides to be used must have very short preharvest intervals. A fourth factor complicates management in grapes. It is likely that sprays can be withheld until 15° Brix, when risk appears to increase markedly. This has a great benefit in terms of resistance management and control cost. However in our chemical control trials in 2014, it was apparent that infested berries were often in the interior of clusters. Adult flies may explore the spaces between berries, reaching protected areas in which to lay eggs (Fig 3 shows another invasive drosophilid, African fig fly, Zaprionus indianus, emerging from within a grape cluster).

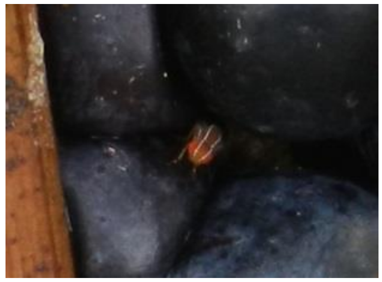

Fig. 3. African fig fly, *Zaprionus indianus*, emerging from the interior of a grape cluster in a Petit Verdot block in Virginia.

Berry closure (also known as cluster closure or berries touch in cluster) occurs much earlier than 15° Brix. No matter how effective the insecticide, it will be impossible to get coverage on fruit surface on berries protected within the cluster. It may be helpful to apply a protective spray just before clusters close, even though berries are not yet at high risk, in order to create some protection while berry services are exposed.

Surround is an OMRI-approved insecticide that is registered on grapes, with a 0-day PHI. Some growers have provided anecdotal evidence of its efficacy against SWD. This could be a valuable part of a resistance management program for SWD. Data need to be collected on its efficacy relative to other materials, both organic and synthetic [Entrust (spinosad), Delegate (spinetoram), malathion, and a pyrethroid such as or Tombstone (cyfluthrin) or Baythroid (β-cyfluthrin)]. These materials are among those currently included for SWD in our Pest Management Guide (Pfeiffer et al. 2014).

Surround may be an effective material to apply as a barrier at berry closure. One goal of this project will be to evaluate the ability of such an early application in preventing infestation in the interior of the cluster.

Sole reliance upon insecticides may not be a sustainable approach for SWD. We are currently surveying for parasitoids of SWD and AFF in Virginia in caneberry, grape and blueberry systems. We would like to see if Surround application affects the ability of parasitoids to attack SWD eggs in treated fruit. We currently have both SWD and AFF in colony, which can support such behavioral studies.

E. Progress and results:

1) Determine efficacy of kaolin relative to synthetic and other organic insecticides against SWD in ripening grapes, and 2) Determine impact of kaolin applied at berry closure in minimizing SWD infestation at harvest,

Crop: Grape (Pinot Noir)

County: Amherst Co., Va.

Plot size: Each rep consisted of 2 adjacent vines (referred to as 'pairs')

Treatments:

June 25: Surround WP (25 lb/acre) or Untreated; replicated 8 times

August 11 and 18

(replicated 2 times over June 25 Surround and Untreated vines):

1. Spinetoram (Radiant SC*) 12 oz/acre
2. Pyrethroid (Mustang Max) 8 oz/acre
3. Kaolin (Surround WP) 25 lb/acre
4. Untreated;

* Note: Radiant SC contains same active ingredient (spinetoram) as Delegate WG

Treatment protocol:

All treatments were applied as foliar sprays by hand using a CO_2 powered backpack sprayer set at 40 psi with a single wand equipped with an 8008VS stainless steel spray tip. Treatments were applied in the fruit zone until run-off.

Surround treatments were applied on 25 June prior to cluster closure. Pairs of vines were either sprayed with Surround WP or untreated.

Late season treatments were applied on 11 and 18 August over the 25 June treatments. Each treatment was applied to two pairs of Surround treated vines and two pairs of non-treated vines. Plots were sampled for prior to treatments on 11 August, and again on 14 August (3 DAT), 18 August prior to the second treatment application (7 DAT), and 25 August (7 days after second treatment).

Sampling protocol:

In a pre-spray sample on 11 August, one cluster of grapes was collected from each pair of vines to be treated. All grapes were then dissected and inspected for *Drosophila* injury and / or presence. Very little injury and no drosophila 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 grape clusters were then dissected and inspected for *Drosophila* injury and / or presence. Percent injured berries were calculated. Sugar content was calculated from 10 randomly selected berries using a refractometer.
The treatment source of variation for percent damaged berries on Aug 11, 14, and 25 was not significant ($P > 0.05$), but was highly significant ($P < 0.01$) on Aug 18. On August 18, the percent injured berries in the Untreated + Untreated treatment was significantly higher than in all the other treatments except the Untreated + Surround and the Surround + Untreated treatments. **Surround was effective when applied at cluster closure and late season. On vines treated at berry closure with Surround, control provided by late season application of Surround was not different from that provided by Mustang Max or spinetoram. On vines with no berry closure treatment, Surround was less effective.** Also on Aug 18, the percent injured berries in the untreated + Surround treatment was significantly higher than the Untreated + Mustang Max and Surround + Mustang Max treatments (Table 1).

Table 1. Effect of Pre-cluster closure Surround plus late season insecticide treatments on at-harvest berry damage, Ankida Ridge Vineyard, Amherst, VA. 2015.

Sample Date:	8-11	8-14	8-18	8-25
DAT:	0 (Pre)	3	7	7
Avg. Brix:	13.3	15.5	19.3	20.5
Trt. No.*	Pct. Damaged Berries (+ SEM)			
N-4	4.3 (4.29)	0.0 (0.0)	9.0 (0.12) a	13.8 (2.43)
N-3	0.0 (0.0)	4.7 (0.55)	7.6 (1.13) ab	9.9 (4.57)
S-4	3.9 (0.45)	2.7 (2.70)	6.0 (0.14) abc	13.9 (3.66)
S-3	1.2 (1.16)	0.0 (0.0)	4.4 (1.59) bcd	4.5 (0.23)
N-1	2.3 (2.33)	3.7 (3.70)	4.0 (0.55) bcd	7.5 (2.18)

S-1	1.0 (0.96)	5.1 (1.55)	2.6 (0.27) bcd	3.6 (0.44)
N-2	5.8 (1.16)	4.9 (0.69)	2.6 (0.48) cd	5.3 (2.91)
S-2	1.1 (1.06)	0.0 (0.0)	1.1 (1.08) cd	7.0 (6.98)
	NS	NS	$P < 0.01$	NS

Surround treatments applied 25 June prior to cluster closure.
Late-season treatment dates: 11 Aug, 18 Aug.
*Key to Treatment Numbers:

S-1: Surround (June 25) + Radiant (Aug 11 and 18)
S-2: Surround (June 25) + Mustang Max (Aug 11 and 18)
S-3: Surround (June 25) + Surround (Aug 11 and 18)
S-4: Surround (June 25) + Untreated (Aug 11 and 18)
N-1: Untreated (June 25) + Radiant (Aug 11 and 18)
N-2: Untreated (June 25) + Mustang Max (Aug 11 and 18)
N-3: Untreated (June 25) + Surround (Aug 11 and 18)
N-4: Untreated (June 25) + Untreated (Aug 11 and 18)

The **treatment source of variation for percent injured berries** was not significant ($P > 0.05$) for Aug 11, 14, and 25, according to ANOVA, but was **highly significant ($P < 0.01$) for Aug 18, close to normal harvest**. Statistical analysis was performed on arcsine transformed data, and actual treatment means are shown in Table 2. Means within a column by date followed by the same letter are not significantly different (P < 0.05; LSD).

During the harvest period (August 15-25) a comparison of the percent reduction of inured berries in treatment plots relative to treatment N-4 (Untreated June 25 + Untreated Aug 11 and 18) indicates that on August 18 and 25**, all treatments had 15.1% to 88.0% reduction in damaged berries, and on August 25 all treatments (except for treatment S-4 [Surround + Untreated]) had 28.5% to 74.0% reduction in damaged berries (Table 2)**.

Table 2. Mean percent damage and percent damage reduction compared to N-4 (Untreated + Untreated) during harvest period.

	18-Aug		25-Aug	
Treatment	Pct. Damage	PDR*	Pct. Damage	PDR*
Surround + Radiant	2.59	71.1%	3.60	74.0%
Surround + Mustang Max	1.08	88.0%	6.98	49.6%
Surround + Surround	4.37	51.4%	4.54	67.2%
Surround + Untreated	6.02	33.0%	13.94	-0.6%
Untreated + Radiant	4.00	55.5%	7.50	45.8%
Untreated + Mustang Max	2.65	70.5%	5.35	61.4%
Untreated + Surround	7.62	15.1%	9.90	28.5%
Untreated + Untreated	8.98	--	13.85	--

*PDR = percent damage reduction compared to treatment N-4 (Untreated + Untreated)

When combining late season insecticide treatments and just comparing pre-cluster closure Surround-treated and Untreated treatments, the treatment source of variation for at-harvest percent damaged berries was not significant ($P > 0.05$) for all sample dates. Some treatments had high variability, and further work should increase the number of clusters sampled. However, the Surround pre-cluster closure treatment damage was reduced by a range of 20.7% to 43.1% compared to the untreated pre-cluster closure treatment (Table 3).

Table 3. Effect of Surround and untreated pre-cluster closure treatments on at-harvest berry damage, Ankida Ridge Vineyard, Amherst, VA. 2015.

Pre-Cluster Treatment	Sample Date			
	8-11	8-14	8-18	8-25
	Pct. Damaged Berries (+ SEM)			
Surround	1.77 (0.59)	1.96 (1.00)	3.51 (0.79)	7.26 (2.14)
Untreated	3.11 (1.26)	3.32 (1.03)	5.81 (1.01)	9.15 (1.69)
PDR*	43.1%	41.0%	39.6%	20.7%

*PDR = percent damage reduction in Surround pre-cluster closure compared to Untreated.
Surround treatments applied 25 June prior to cluster closure.

3) Determine impact of kaolin on parasitization rates in SWD in the field,

Sentinel traps for parasitoids (Hymenoptera) of drosophilids were placed in four different small fruit cropping systems during the 2015 field season: cherry, caneberry, blueberry, and wine grape. Traps were placed on the edge and interior of each growing system, and two bait types were used for each site: banana or seasonal fruit respective to the cropping system. In the laboratory, trap baits were seeded with larvae of *Drosophila melanogaster*, *Drosophila suzukii*, or *Zaprionus indianus*, or left uninfested as a control before being placed in the field. Trap baits were left in the field for 3-4 d before being collected and returned to laboratory, where larvae were allowed to finish development in rearing cups. Rearing cups were checked periodically for parasitoid emergence from fly pupae. Active trapping occurred for a total of 21-24 d at each site. Two species of parasitoid were reared from the sentinel trap baits in significant numbers: *Leptopilina* spp. (Figitidae), a larval parasitoid, and *Pachycrepoideus vindemiae* (Pteromalidae), a pupal parasitoid, with *Leptopilina* the most abundant. Both parasitoid species were reared from the cherry orchard, only *Leptopilina* was reared from the caneberry site, and **no parasitoids were reared from the blueberry and wine grape systems, in blocks untreated with Surround**. Both species were reared from *D. melanogaster*, and one individual *P. vindemiae* was reared from *D. suzukii*. No parasitoids were reared from *Z. indianus*.

4) Determine ability of parasitoids to attach SWD in sentinel berries.

In the laboratory, preliminary studies on parasitization rates of the *Leptopilina* spp. were performed on *D. melanogaster*, *D. suzukii*, and *Z. indianus*. Results showed 27% parasitization success on *D. melanogaster*, with 43% more fly mortality than the control. **On *D. suzukii*, there was 0% parasitization success due to effective immune responses, and there was only 12% more mortality than the control, but 73% of emerged flies showed signs of attempted parasitization**. Only 10% of *Z. indianus* larvae showed signs of attempted parasitization, and had 0% parasitization success with minimal difference in mortality from the control. Further replicates are in progress. Studies on parasitization rates of *P. vindemiae* are to be completed.

F. Dissemination of information, and future plans for project: This research has guided revisions of the Pest Management Guide for Commercial Vineyards and the Virginia Fruit web page. Data have been (and will be) presented at the Entomological Society of America national meeting, and Cumberland Shenandoah Fruit Workers Conference.