TITLE:

EARLY DETECTION AND MANAGEMENT OF SPOTTED WING DROSOPHILA IN RASPBERRY IN NY

DEC-2013 PROGRESS REPORT

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This research is geared toward improving **production** of berry crops through a better understanding of monitoring and control of spotted wing drosophila

Year 2

INTRODUCTION:

Spotted wing drosophila (SWD), originally from Asia, represents a serious challenge for fruit growers in the Northeast and elsewhere (Walsh et al. 2010, Hauser 2011, Lee et al. 2011a). Unlike other fruit flies, this species has the capacity to lay its eggs in ripe, marketable, soft-skinned fruit. Later maturing berries, such as blueberries, fall raspberries and strawberries, appear to be especially vulnerable, although stone fruit, such as peaches and cherries, and grapes are potentially also at risk (Lee et al. 2011b). SWD first appeared in California in 2008 and has been rapidly expanding its distribution ever since. SWD was first observed in the Northeastern region in 2010, became widespread during the end of the 2011 field season causing some economic damage. In 2012, SWD appeared in mid-summer in the Northeast and was responsible for very serious economic damage in fruit crops, particularly raspberry and blueberry, but also day-neutral strawberries in late summer and fall. We also received reports of SWD infesting June-bearing strawberry in North Carolina and one case in upstate NY. In order to keep fruit clean and marketable, growers resorted to treating vulnerable plantings up to twice per week with insecticides.

Berry growers are facing numerous challenges with regards to SWD. An effective monitoring program that provides an early warning of imminent infestation is of paramount importance. The standard adult monitoring tool, using a deli cup with apple cider vinegar as the attractant, eventually captures many SWD and other fruit flies. However, our results for 2012, as well as the results of other investigators, indicate that adult flies are often first caught after infestation has already occurred. In the absence of a better early warning system, growers are probably better off to initiate insecticide treatments as soon as fruit begins to ripen, even though this could result in unnecessary costs (economic and environmental). Therefore, for the second year of this project we focused on assessing the effectiveness and practicality of new lures and/or lure placement as an early warning of impending infestation.

As indicated above, controlling SWD is problematic. As internal feeders, immature life stages are well protected within fruit from pesticides. In addition, flies continually emerge or immigrate into a planting therefore requiring repeated applications (weekly or biweekly) through the harvest period to maintain clean fruit. In addition to improved monitoring, growers need effective insecticides that provide residual control and have short days to harvest restrictions. Adult flies appear fairly susceptible to a number of insecticides (Bruck et al. 2011). However, the flies continually emerge or immigrate into a planting therefore requiring repeated applications (weekly or biweekly) through the harvest period to maintain clean fruit. In addition to the economic costs of these insecticide applications, many of the compounds are detrimental to beneficial insects.

The total economic losses in the Northeast from SWD in 2012 have not been accurately determined, but 30% loss for raspberry and blueberry growers is probably conservative. In the absence of insecticides, losses of 100% due to SWD have been observed in the West. Although SWD appears fairly susceptible to insecticides, most efficacy work has been conducted in the west and/or under laboratory conditions. In 2012, with funding from NARBA, we established a new fall raspberry planting at the NY State Agricultural Experiment Station to be used for insecticide efficacy trials in 2013.

OBJECTIVES:

1. **Evaluate relationship between first adult SWD capture and fruit infestation for different lures and trap placement in raspberry plantings.**

2. **Efficacy of labeled and unregistered insecticides against SWD in raspberry.**

METHODS:

Objective 1. Evaluate relationship between first adult SWD capture and fruit infestation for different lures and trap placement in raspberry plantings.

Two sites with a history of SWD infestation were included in this study. Site 1 was a mixed planting that included June-bearing strawberries, floricane-fruiting raspberries and various stone fruits. Site 2 was an isolated blueberry planting bordered by woods and soybeans. Adult SWD were monitored using standardized deli cup traps baited with one of five lure treatments: apple cider vinegar attractant that also served as drowning solution, fermenting yeast-sugar-water mixture that also served as drowning solution, separate fermenting whole wheat mixture with apple cider vinegar-ethanol drowning solution, DroskiDrink (apple cider vinegar-red wine-raw sugar mixture) that also served as a drowning solution, and a water control (See appendix 2 – supporting photograph 1 and 2 for image of trap configuration and general plot layout). At site 2 a sixth synthetic lure treatment was included. This was a prototype lure that is currently not commercially available. Traps were deployed the week of 27-May 2013 with the exception of the synthetic lure baited traps that were deployed the week of 1-Jul. Traps were monitored and serviced weekly for 12 weeks, thru the week of 19-Aug. Four replicates of each lure treatment were placed in a randomized block design in raspberries and strawberries at site 1, as well as the blueberries at site 2. In addition, four replicates of each lure treatment were placed along the wooded perimeter of both sites in close proximity to the fruit plantings. Potential wild hosts, including wild black raspberry, bush honeysuckle, dogwood, pokeweed, and buckthorn, were noted in the wood perimeter of both sites. When the respective crops began to ripen, fruit samples were collected from each trap location with crops, as well as from randomly selected non-trap associated locations. Samples were held in rearing containers under ambient laboratory conditions until adult emergence at which time total adult fruit flies were quantified. Adult fruit flies were separated into male SWD, female SWD, and other *Drosophila* species. Growers were kept informed of trap and fruit assessments through the NYS-IPM SWD trap network.

Objective 2. Efficacy of labeled and unregistered insecticides against SWD in raspberry.

Three trials were included in an effort to evaluate effectiveness of labeled and unregistered insecticides.

<u>Trial 1</u> was a broad evaluation of labeled in unlabeled insecticides, with or without an added phagostimulant. These trials were conducted on individual fruiting canes in a commercial vineyard. Whole tip cuttings with ripe fruit were brought back to the lab and SWD were exposed under laboratory conditions to the treated tissue 1d, 3d and 7d after application. Adult survival was recorded after 24h. Treatments were applied using a 4-oz bottle furnished with an atomizing top. Treatments were as follows in table 1.

Treatment	Sugar	Rate Product/A
Delegate	Yes	3 oz
Delegate	No	3 oz
Assail	Yes	5 oz
Assail	No	5 oz
Entrust SC	Yes	4 fl oz
Entrust SC	No	4 fl oz
HGW 86	Yes	16.9 fl oz
HGW 86	No	16.9 fl oz
Mustang Max	No	4 fl oz
Malathion 5EC	No	3 pts
Sugar only	Yes	-
Water only	No	-

Table 1. Description of insecticide treatments used for phagostimulant trial lab bioassay using fall raspberry. Geneva, NY, Sept-2013. HGW 86 is an unregistered material by DuPont with the active ingredient cyazypyr. Sugar was added at a rate of 2 lb/100 gallon rate.

Trial 2 was an evaluation of an experimental product provided by DuPont. We used a two-year old planting of the primocane raspberry variety Caroline planted at Darrow Farm at NYSAES in Geneva, NY in the summer of 2012. The planting consists of five rows, each row approximately 40 m in length and 10' spacing between rows (mowed grass middles). For this experiment we used four rows (each row = block) with 7 treatments per block with each plot 5.0 m in length. We used 50 gallons per acre rate using a Solo model 416 electric 5-gallon backpack sprayer, equipped with a twin spray teejet flat fan fine nozzle. Treatments were as follows in Table 2, and were applied on 29-Aug, 6-Sept, 13-Sept, and 18-Sept 2013 (the interval between treatment 3 and 4 was reduced due to rain showers that persisted the day of, and days following treatment 3 – see appendix 1 for detailed weather and precipitation information).

Trt	Description	Rate/A
A	HGW 86 + LI 700, Low	13.5 fl oz
B	HGW 86 + LI 700, Mid	16.9 fl oz
C	HGW 86 + LI 700, High	20.5 fl oz
D	HGW 86 + LI700 + sugar	16.9 fl oz
E	Delegate	6 oz
F	Water + LI 700	-
G	Water + LI 700 + Sugar	-

Table 2. Description of treatments used for Dupont HGW 86 trial, Geneva, NY, August 2013. Sugar was added at the rate of 2 bl/100 gallons water.

Infestation rates were measured by collecting 15 marketable berries from each replicate, which were held at ambient laboratory conditions until adult drosophila eclosion at which time the total number was recorded. Fruit samples were collected on 5-Sept, 12-Sept, 20-Sept, 27-Sept, 4-Oct, 10-Oct, and 18-Oct 2013.

Trial 3 was a trial in primocane raspberry assessing season long efficacy of reduced risk insecticides (Delegate and Assail) with and without a feeding stimulant (sugar) and a third treatment that tested the efficacy of rotating compounds across different modes of action (spinosyn, neonicotinoid, OP, and pyrethroid). A commercial planting was used for this study. The trial included four replicates with each treatment replicate being applied to 20m within a single row using a Solo model 416 electric 5-gallon backpack sprayer, equipped with a twin spray teejet flat fan fine nozzle. Treatments were made on 20 Aug, 27 Aug, 3 Sept, 10 Sept, 17 Sept, 24 Sept 2013. Treatments were as follows in Table 3.

Table 3. Description of treatments used for trial assessing reduced risk insecticides throughout the fall raspberry season. Geneva, NY, Fall-2013

Trt.	Description	Rate/A
Reduced Risk +	2 Delegate (+ sugar) rotated with 2 Assail (+ sugar)	-Delegate (3 oz) -Assail (5 oz) -Sugar (2 lb/100 gallons)
Reduced Risk -	2 Delegate rotated with 2 Assail. No sugar	-Delegate (3 oz) -Assail (5 oz)
Active Ingredient Rotation	2 Delegate (+ sugar) & 2 Assail (+ sugar), 2 Mustang Max	-Delegate (3 oz) -Assail (5 oz) -Sugar (2 lb/100 gallons) -Mustang Max (4 fl oz)

Table 3. Description of treatments used in large plot insecticide trial in which 3 different rotations of products were compared. Geneva, NY, August-2013. Rotation involved 2 applications of Delegate, then 2 applications of Assail, repeated for reduced risk or rotated to Mustang Max for rotational program.

Infestations rates were measured by collecting 15 marketable berries from each side of each replicate. Samples were held at ambient laboratory conditions until adult drosophila eclosion at which time the total number was recorded.

RESULTS BY OBJECTIVE:

Objective 1: The seasonal occurrence of SWD followed a similar pattern as had been observed during the season of 2012. First detection was from the week of 10-Jun in a trap baited with a fermenting dough lure in a woods perimeter (Table 4). This date was 3 weeks earlier than recorded in 2012. In 2012 the trap lure used was apple cider vinegar. The date of first capture in 2013 using apple cider vinegar was within 7d of the calendar date of first capture in 2012. Results comparing different lures (Table 4) indicates that the fermenting bait + apple cider vinegar lure provided the first capture at both sites, and generally captured the most flies during each sampling interval (See appendix 2 – supporting photograph 3 for an image of this trap configuration). In weeks that the synthetic lure was deployed at site 2, captures were comparable, and sometimes surpassed, total captures in fermenting dough +apple cider vinegar baited traps. Other baits including apple cider vinegar, yeast-sugar-water mixture, and DroskiDrink consistently captured fewer flies than either the fermenting bait + apple cider vinegar or synthetic baited traps.

Date for first trap catch and first reared SWD from raspberry fruit for site 1 occurred in the same week (Figure 1). It should be noted that the grower did elect to treat with insecticide after detection of SWD. Higher rates of infestation were found in fruit at the end of the fruiting season as fruit was becoming scarcer, and the grower was no longer harvesting. Date for first trap catch at site 2 was on 11-Jun, from a woods trap (Figure 2). First trap catch from traps in the crop occurred the week of 15-Jul. First reared SWD from blueberry fruit for site 2 occurred the week of 22-Jul.

Table 4. Total number of spotted winged drosophila captured in four 32-oz. deli-cup traps with different bait treatments (4 traps per treatment), from different habitats at two sites in Geneva, NY. 27-May thru 19-Aug, 2013. Shade color shows density (higher numbers in orange to red).

Week--->	27-May	3-Jun	10-Jun	17-Jun	24-Jun	1-Jul	8-Jul	15-Jul	22-Jul	29-Jul	5-Aug	12-Aug	19-Aug	Grand Total
Site 1	0	0	0	0	0	1	1	14	60	89	224	529	1130	2048
Raspberry	0	0	0	0	0	1	0	4	4	19	110	403	530	1071
Apple Cider Vinegar	0	0	0	0	0	0	0	0	0	0	2	62	62	126
DroskiDrink	0	0	0	0	0	0	0	1	0	10	14	102	99	226
Fermenting Bait + ACV/ETOH	0	0	0	0	0	1	0	1	2	2	62	153	281	502
Water/Control	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Yeast +Sugar	0	0	0	0	0	0	0	2	2	5	32	86	88	215
Strawberry	0	0	0	0	0	0	0	0						0
Apple Cider Vinegar	0	0	0	0	0	0	0	0	x	x	x	x	x	0
DroskiDrink	0	0	0	0	0	0	0	0	x	x	x	x	x	0
Fermenting Bait + ACV/ETOH	0	0	0	0	0	0	0	0	x	x	x	x	x	0
Water/Control	0	0	0	0	0	0	0	0	x	x	x	x	x	0
Yeast +Sugar	0	0	0	0	0	0	0	0	x	x	x	x	x	0
Woods	0	0	0	0	0	0	1	10	56	70	114	126	600	977
Apple Cider Vinegar	0	0	0	0	0	0	1	1	0	14	6	15	26	63
DroskiDrink	0	0	0	0	0	0	0	0	14	17	33	15	80	159
Fermenting Bait + ACV/ETOH	0	0	0	0	0	0	0	5	25	11	46	50	433	570
Water/Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yeast +Sugar	0	0	0	0	0	0	0	4	17	28	29	46	61	185
Site 2	0	0	1	0	0	0	0	3	58	204	465	660	1645	3036
Blueberry	0	0	0	0	0	0	0	3	21	137	301	449	542	1453
Apple Cider Vinegar	0	0	0	0	0	0	0	0	1	4	7	41	59	112
DroskiDrink	0	0	0	0	0	0	0	0	1	32	44	51	82	210
Fermenting Bait + ACV/ETOH	0	0	0	0	0	0	0	1	12	26	116	88	119	362
Scentry Lure	x	x	x	x	x	0	0	1	5	52	55	103	107	323
Water/Control	0	0	0	0	0	0	0	0	0	0	0	1	1	2
Yeast +Sugar	0	0	0	0	0	0	0	1	2	23	79	165	174	444
Woods	0	0	1	0	0	0	0	0	37	67	164	211	1103	1583
Apple Cider Vinegar	0	0	0	0	0	0	0	0	0	2	3	57	48	110
DroskiDrink	0	0	0	0	0	0	0	0	22	13	50	13	171	269
Fermenting Bait + ACV/ETOH	0	0	1	0	0	0	0	0	4	13	50	59	388	515
Scentry Lure	x	x	x	x	x	0	0	0	5	29	17	30	425	506
Water/Control	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yeast +Sugar	0	0	0	0	0	0	0	0	6	10	44	52	71	183
Grand Total	**0**	**0**	**1**	**0**	**0**	**1**	**1**	**17**	**118**	**293**	**689**	**1189**	**2775**	**5084**

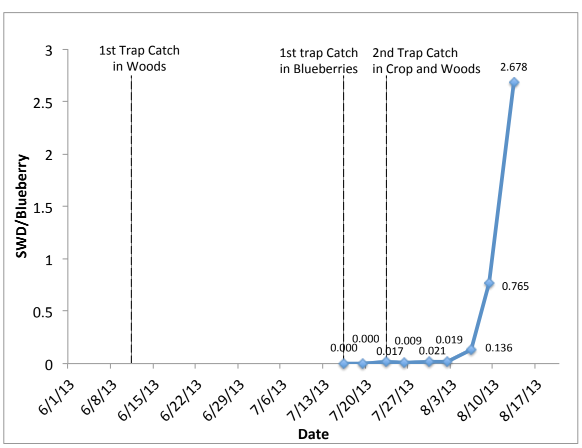

Figure 1. Mean SWD per raspberry fruit from floricane-fruiting raspberry planting from site 1 in which trap monitoring was in place in the crop and woods perimeter. Geneva, NY. Summer 2013.

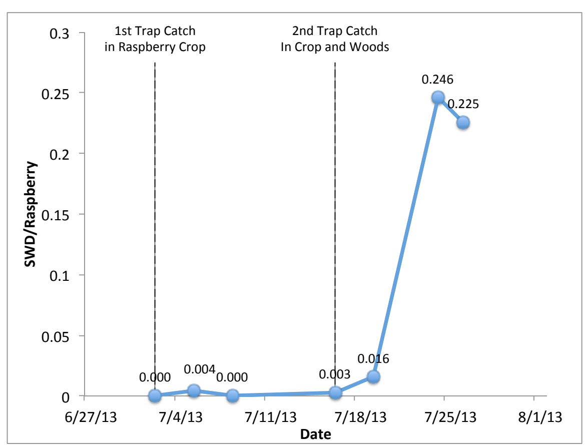

Figure 2. Mean SWD per blueberry fruit from blueberry planting from site 2 in which trap monitoring was in place in the crop and woods perimeter. Geneva, NY. Summer 2013.

Objective 2

Trial 1: Data for trial 1 comparing products, and combinations of products plus phagostimulant, indicated that Mustang Max resulted in the highest proportion of dead adult SWD at all days post-application (Figure 3). Products tested with the addition of a phagostimulant generally exhibited increased mortality and a prolonged period of efficacy. The one exception was data for HGW 86 SE that did not indicate any benefit from addition of a phagostimulant. Proportion of SWD mortality for each product declined between 3d and 7d post-application.

Trial 2: Data for trial 2 indicates that cyazypyr provides a level of control for spotted wing drosophila that is superior to an untreated check and not different from the local standard Delegate WG (Figure 4). Adding sugar to HGW did not seem to make a measurable difference in cyazypyr efficacy. Data also indicate that HGW 86 SE has longer residual activity (3 weeks) than the standard (1 week) used in this trial (Figure 5).

Trial 3: Data for trial 3 did not indicate a significant difference between the three different treatment rotations (Figure 6). Infestation rates were relatively high across all treatments. Average berry weight for this trial was 2.15g per berry.

DISCUSSION:

Early season monitoring with various lure treatments provided some important information about our interest in using monitoring as an early warning for SWD infestation. Fermenting bait + ACV-ETOH drowning solution and the synthetic lure provided higher rates of SWD capture than other baits assessed in this trial. At site 1 trap catch in the crop and woods preceded measured fruit infestation by three days. At Site 2 trap catch in the crop preceded measured fruit infestation by 7 days and trap catch in the woods preceded infestation by over a month.

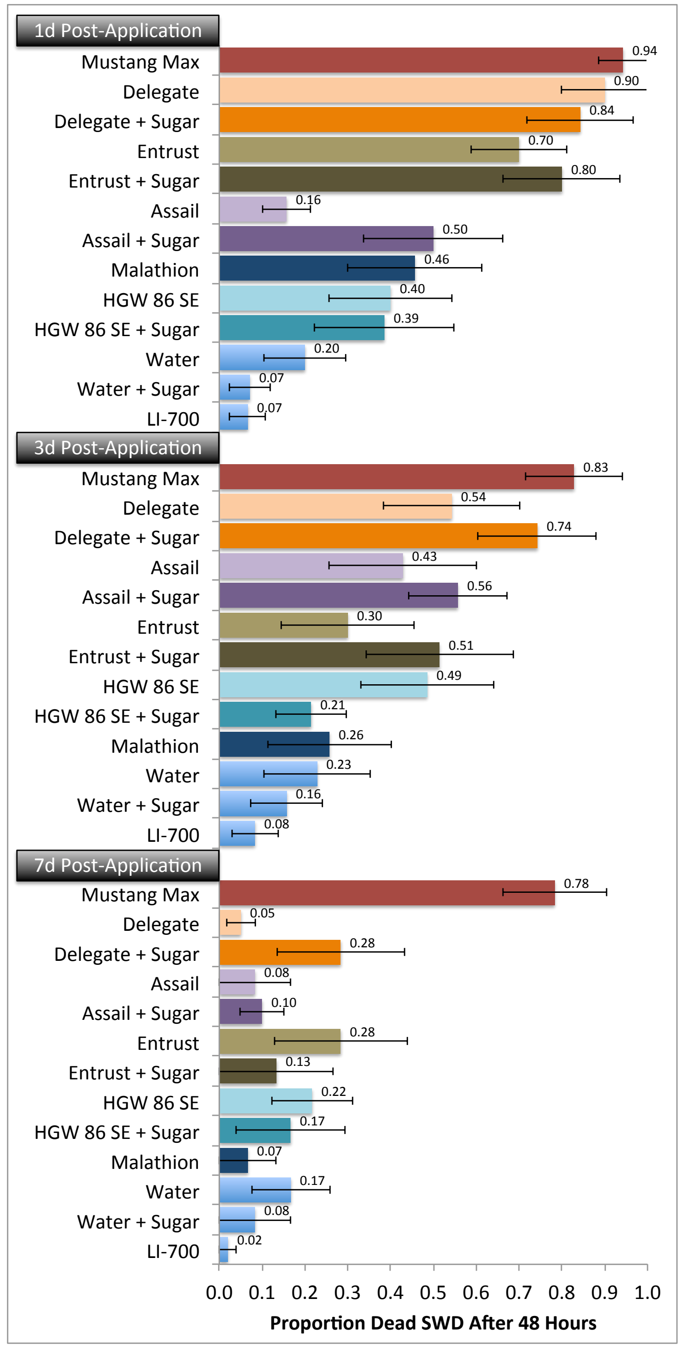

Figure 3. Evaluation of insecticides conducted on individual fruiting canes in a commercial primocane raspberry planting. Treated raspberry fruit with attached receptacles were brought back to the lab 1d, 3d and 7d after application. Adult SWD were confined under laboratory conditions to the treated fruit and adult mortality was recorded after 24h and 48h. Geneva, NY, Summer-2013.

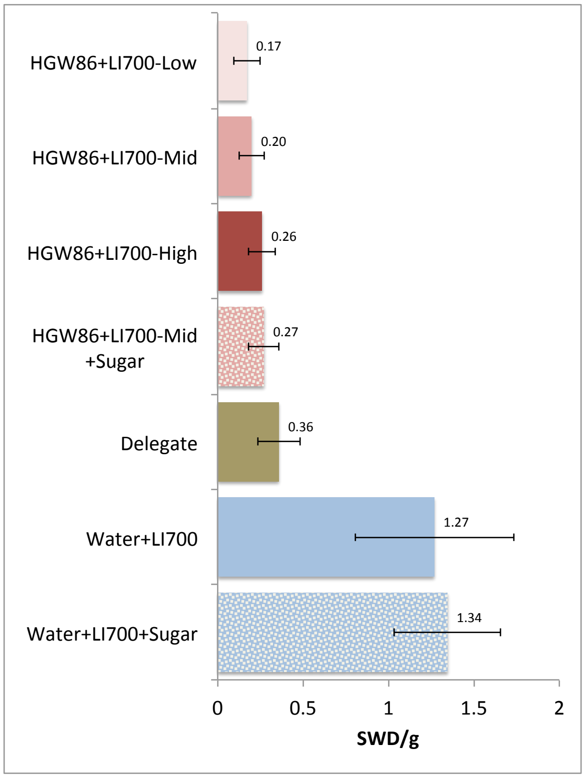

Figure 4. SWD/g of fruit sampled over a 4 week period from primocane raspberry plots that had received weekly applications of the experimental insecticide HGW 86 SE. Geneva, NY, Summer-2013.

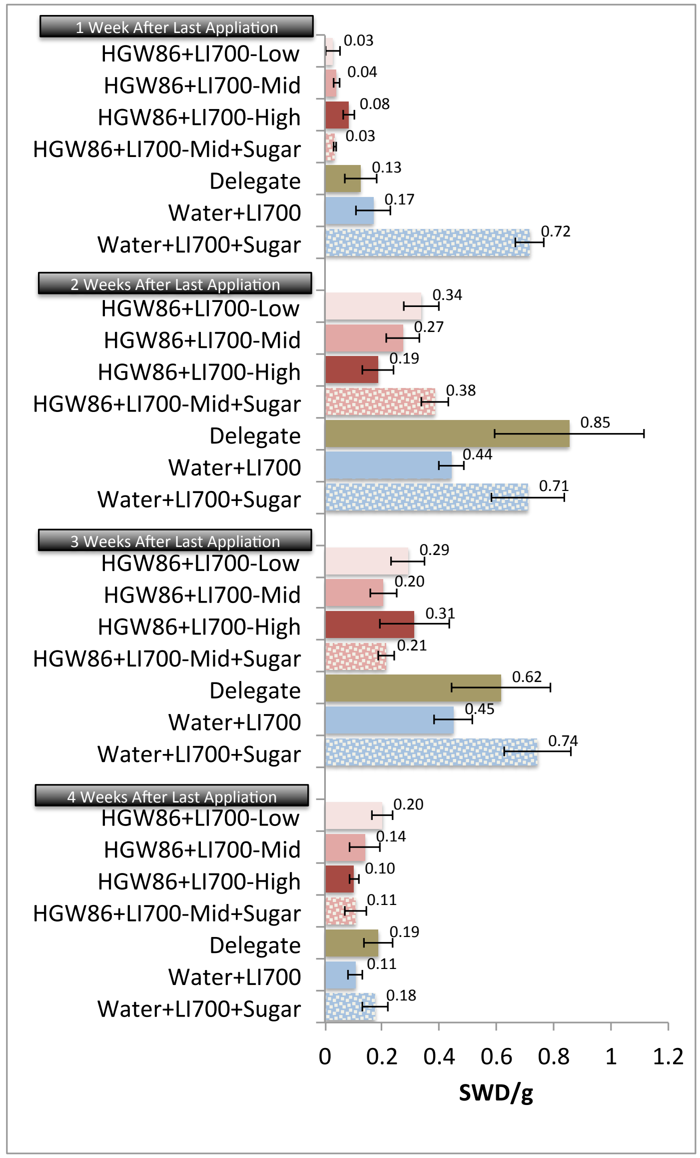

Figure 5. SWD/g of fruit sampled from primocane raspberry plots in weeks subsequent to the final treatment with experimental insecticide HGS 86. Geneva, NY, Summer – 2013.

Despite trap captures in crops and infestations occurring within one week of each other, the level of infestation early in the fruiting season was relatively low (4 to 17 berries per 1000) and could be tolerable under some circumstances. This may give the grower enough advance notice of significant infestation to provide an indication to begin treatment. It should be noted that the grower in these experiments elected to treat both of these plantings with insecticide. It is possible that the increased infestation rates at the end of the monitoring period for these experiments were measured after the grower had stopped treatment, but this needs to be verified.

Insecticide trial 1 provides some insight as to the "knock down" effect of the different products tested on adult flies. These data will be more meaningful once SWD biology is better understood. If a commercial planting is persistently re-infested by SWD

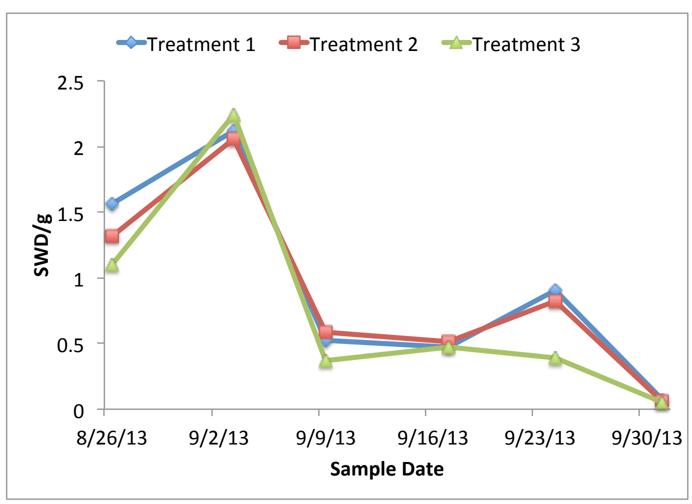

Figure 6. SWD/g of fruit sampled from 20m primocane raspberry plots that had received different insecticide treatment rotations. Geneva, NY, Summer-2013.

over the timeframe of a week following an application, products like Mustang Max could provide superior control than those that have poorer residual effect. Note that pyrethroids such as Mustang Max are very toxic to beneficial insects such as pollinators. The experimental product HGW 86 SE deserves particular mention in regards to persistence in that although it did not fair very well in trial one, it did demonstrate a level of control comparable to the standard in trial two. In addition it seemed to have a residual effect for up to three weeks. It is difficult to draw any conclusions from trial 3, in which different product rotations were compared. One possible explanation for the very high rates of infestation in this trial was the fact that there was a considerable area of the planting that was untreated throughout the experiment. Moreover, the trial was not initiated until several weeks after ripe fruit was present in the field. While the experimental plots were relatively large (20m), the untreated area may have provided a refuge for SWD that increased re-infestation pressure on our experimental plots that would not have existed if a whole planting were being treated.

Great strides have been made during the summer of 2013 to better understand some of the monitoring and management strategies available for SWD. Areas of future research related to monitoring and trap design include continued development of an optimal lure, better understanding of SWD overwintering biology, and the possibility of using the trap itself as a management tool. Current practices and recommendations for insecticide treatment for SWD include a spray interval of seven days or less. Based on these results, further research is necessary to assess whether some of these products could provide a longer intervals of protection. This is a critical area of research that has implications ranging from resistance management to the environmental sustainability of growing crops impacted by SWD.

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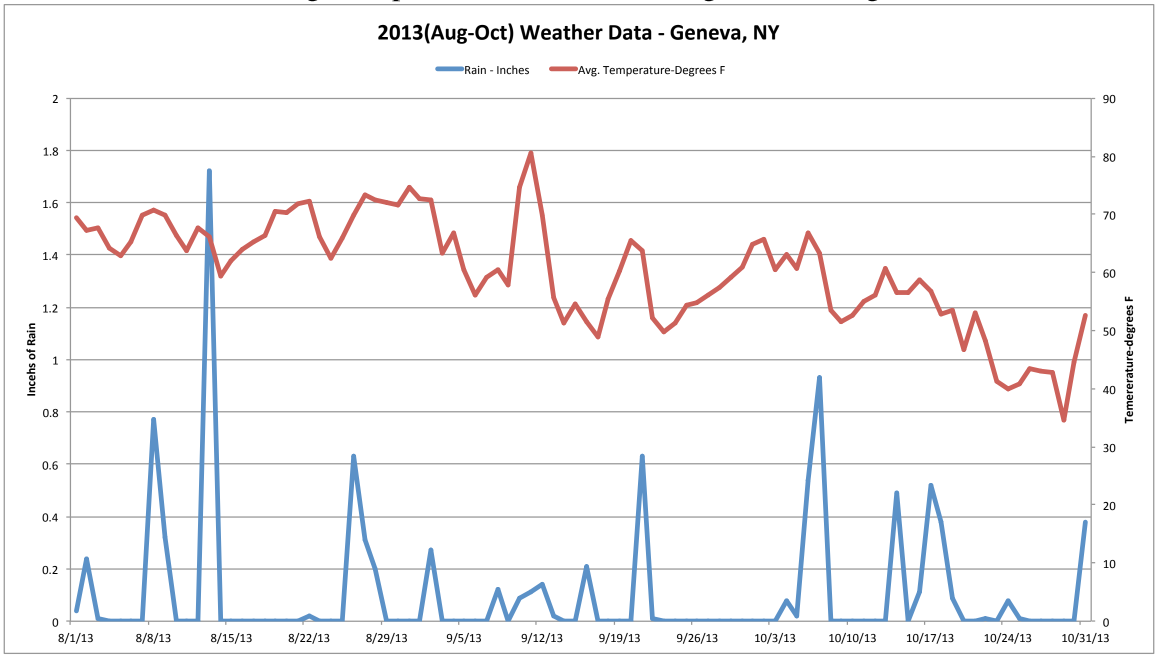
Appendix 1: Supporting weather data

Rain (inches) and average temperature data from 1-Aug 2013 through 31-Oct for Geneva, NY.



APPENDIX 2 – SUPPORTING PHOTOGRAPHS

Photograph 1. Standardized deli-cup trap utilized for SWD monitoring in floricane raspberries. Geneva, NY, summer-2013.

Photograph 2. Trial comparing different lure treatments in standardized deli-cup traps for SWD in June-bearing strawberries. Geneva, NY, Summer - 2013.

Photograph 3. Fermenting bait lure with apple cider vinegar/ethanol drowning solution. This lure treatment combination outperformed other lures assessed in this trial. Geneva, NY, Summer-2013.