Purdue Entomology Capstone Research

Efficacy of experimental repellent (ECS-F-539) compared to commercial insecticide standards for managing spotted wing drosophila *Drosophila suzukii* (Diptera: Drosophilidae)

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Abstract

Spotted wing drosophila (SWD) *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) is an invasive species of vinegar fly found throughout North America and Europe. SWD infests many fruits such as blueberries, blackberries, cherries, grapes, peaches, raspberries, strawberries and more by laying their eggs within healthy fruits as they are ripening and renders the infested fruit unmarketable. The objective of this project was to investigate the use of a naturally produced compound to repel populations of this insect. The experimental repellent, ECS-F-539 (Locus Agricultural Solutions, Greater San Diego Area, CA), has shown a high degree of efficacy in laboratory conditions to protect small fruits from SWD oviposition. The repellent was tested against two commercial standards, Delegate WG (Dow Agrosciences, Indianapolis, IN) and Mustang Maxx 0.8EC (FMC, Philadelphia, PA), along with an untreated control on raspberries at the Throckmorton Purdue Agricultural Center. The experiment was arranged in a randomized complete block design with four replications. Each experimental unit was 20 feet of a row of raspberries. Two successive applications were applied three days apart with a handheld CO2 pressurized spray boom. The fruit were classified as either infested or un-infested after being examined in the laboratory. There were no significant differences among the percentages of un-infested fruit in the treatments in this study. The repellent, ECS-F-539, did not reduce the percentage of infested fruit compared to the untreated control. Because we know that commercial growers and researchers are receiving good to excellent control with the commercial insecticide standards in our trial, it can be concluded that the application method may require improved spray coverage and/or an increased duration of spray applications. Furthermore, ECS-F-539 may need an adjusted application rate to provide acceptable levels of control on raspberries.

Key Words *Drosophila suzukii,* experimental repellent, ECS-F-539, Delegate WG, Mustang Maxx 0.8EC, raspberries

Introduction

Since the introduction of spotted wing drosophila (SWD) *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) into the United States in 2008 (Bolda M. P., 2010), it has spread through the transport of infested fruit throughout the continent and the world (Baker R., 2010). This invasive species of vinegar fly originated from Eastern Asia and has a broad spectrum of hosts. Common fruit that SWD infest include blueberries, blackberries, cherries, grapes, peaches, raspberries and strawberries. The adult SWD lay eggs into ripening fruit, the eggs hatch, and larva feed on and contaminate the fruit. This renders the fruit unmarketable. SWD then pupates inside the fruit. In a few days, adults will emerge who will then mate and lay eggs multiple times within the couple weeks they live. Drosophilans, including SWD, are known for their frequent and short generation times. Without taking preventive measures, farmers can lose a large percentage of their harvest to these flies. From data collected in 2008, it was estimated that SWD has the potential to cause over $511 million in damage just in California, Washington and Oregon (Bolda M. P., 2010). Currently, the only measures for combating SWD infestation are frequent pesticide applications. Due to their short generation times, resistance to current commercial pesticides will be inevitable in the near future. This calls for the innovation of current methods and creation of new insect pest management techniques.

The experimental repellent, ECS-F-539, is one of these new innovations. It was produced and provided by Locus Agricultural Solutions, based in San Diego, California. Reported here are the results of the first field trial of this experimental repellent. The active ingredient, a naturally occurring compound called butyl anthranilate, has been shown to mask the emission of CO_2 emitted from berries during their ripening and thus avoids female SWD detection (Pham C. K., 2015).

This project looked to test in the field the experimental repellent, ECS-F-539, against current commercial pesticide standards, specifically Mustang Maxx 0.8EC (active ingredient: zeta-cypermethrin) and Delegate WG (active ingredient: spinetoram). Both insecticides have been identified in the Midwest Fruit Pest Management Guide 2016 as effective insecticides to control SWD populations (Bordelon B., 2016). Raspberries (Heritage variety) were used at the Throckmorton Agricultural Center in Tippecanoe County, IN for testing. This agricultural center has had serious problems with SWD populations in past years.

Materials and Methods

Monitoring

SWD was monitored with the Trece SWD trap and the Trece Pherocon SWD lure throughout the summer to determine its presence at Throckmorton Agricultural Center. Collections of samples were performed once a week. There is currently no set economic injury level for SWD, so spraying should commence directly after detection of a single fly (Isaacs R., 2013).

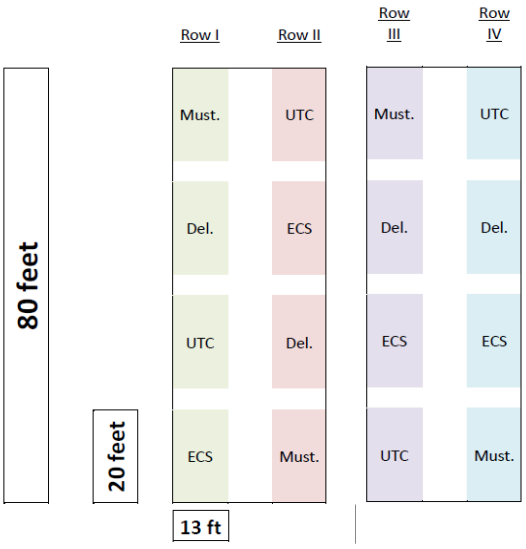

Figure 1 - Complete randomized block spray plan.

Picture 1 - Range of raspberries stages removed directly before and also 24 hours after the first spray.

Plot Area

Each treatment was 20 feet long by 13 feet wide. Replications of each treatment were arranged in a complete randomized block design (Figure 1).

Applications

Before spraying, all overripe, ripe and reddening raspberries on the canes were removed (Picture 1), to remove any current infestation that may skew the harvest data. A ripe berry is one that is ready for harvest and is currently marketable. The day after the first spray, a similar second raspberry removal was performed to insure no SWD were present from before the sprays.

Treatments were applied with a CO_2 pressurized spray boom with two nozzles pressurized at 25 psi. The sprayer's release rate was 18.9 ml/sec. Each side of a treatment row was sprayed for 18 seconds, totaling 680 mL of treatment sprayed onto 20 feet of raspberries. 2720 mL (0.719 gallons) were sprayed for a single treatment across all 4 rows. Personal protection equipment (PPE) was worn according to insecticide labels. A protective suit was worn when applying ECS-F-539 because the experimental repellent's toxicity to humans has yet to be characterized (Picture 2).

The original rate of ECS-F-539 was set at 60 mL (7.5% of spray solution) per replication with an addition of 10 mL of Spreader 90 surfactant. This rate was determined from previous lab trials on strawberries performed by Locus Agricultural Solutions (Pacific Ag Research, 2016). This was reduced to 3 mL (0.375% of spray solution) of ECS-F-539 per treatment with no addition of spreader 90 in the second spray timeline due to

Picture 2 – PPE with sprayer. R & D Sprayers: Model SS 3 Nozzle

phytotoxicity (Picture 3 & 4) occurring within 24 hours of the original application. Furthermore, it sprayed on a new treatment area over 4 replications. 3 mL of ECS-F-539 was mixed in 797 mL of water for each replication. Before the beginning of each spray, extra spray mixture was allowed inside the holding tank for priming and filling of the spray boom. The holding tank of the sprayer

Table 1 – Application rates of treatments.

Insecticides/Repellent	Commercial Rate	Applied on Raspberries/treatment	Total Applied over 4 Rows
Mustang Maxx 0.8EC	4 fl. oz./acre	0.71 mL	2.84 ml
Delegate WG	6 oz./acre	1013.50 mg	4053.982 mg
ECS-F-539 (First Spray - Phytotoxicity)	NA	60 mL + 10 mL of "Spreader 90"	240 mL + 40 mL of "Spreader 90"
ECS-F-539 (Second Spray)	NA	3 mL	12 mL

Picture 3 - Burning of Leaf edges.

Picture 4 - Discoloration of berries.

was cleaned after each treatment by using water plus soap and then rinsed with water.

Delegate WG and Mustang Maxx 0.8EC were applied according to label directions at 6 oz./acre and 4 fl.oz./acre, respectively. These treatments were applied in the same manner as described previously.

Treatment(s)	1st Spray	2nd Spray	Harvest
-UTC -Delegate WG - Mustang Maxx 0.8EC	August 19th, 2016	August 22nd, 2016	August 25th, 2016
-ECS-F-539 (Reduced Rate)	August 21st, 2016	August 25th, 2016	August 27th, 2016

Table 2 – Spray Timeline.

Two applications were made at three days apart. Harvest occurred three days after the second spray application. All ripe raspberries found within the center 14 feet of each treatment were collected to avoid any drift bias from adjacent treatments. Infestation was identified by SWD larva presence or obvious signs of damage caused by larva, such as a moist and/or soft structure to the berry or presence of pooled raspberry juices inside the receptacle of the berry (Isaacs R., 2013). Each berry was individually graded as infested or un-infested.

Timelines

Due to signs of phytotoxicity within 24 hours of the original spray of ECS-F-539, a second spray timeline was used for respraying at a reduced application rate (Table 2.). These dates were chosen by checking the berries for ripeness and estimated dates for harvest. The second spray of ECS-F-539 was delayed by a day due to rain.

Results

A total of 7763 raspberries were picked during harvest. 1595 from the untreated control (UTC), 2338 from ECS-F-539 plots, 1638 from Delegate WG plots and 2192 from Mustang Maxx 0.8EC plots.

Treatment	Row	Infested	Un-infested	% Clean
UTC	1	297	197	40
	2	405	150	27
	3	150	109	42
	4	180	107	37
ECS-F-539	1	411	138	25
	2	696	123	15
	3	274	238	46
	4	283	175	38
Delegate WG	1	318	98	24
	2	249	105	30
	3	443	120	21
	4	231	74	24
Mustang Maxx 0.8EC	1	289	270	48
	2	451	291	39
	3	380	143	27
	4	188	180	49

Table 3 – Raw data collected from every treatment across all four rows.

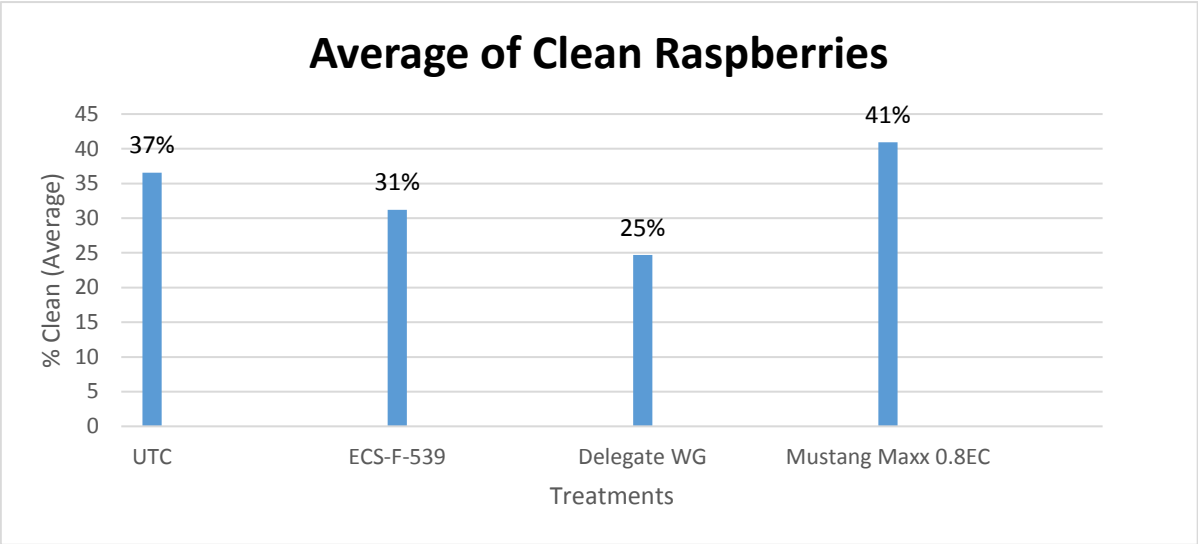

Figure 2 - Average percent of clean berries found across four repetitions and all four treatments.

The average percent of clean berries found in the UTC was 37%, ECS-F-539 was 31%, Delegate WG was 25% and Mustang Maxx 0.8EC was 41% (Figure 2). The average percent of clean berries found per repetition was 34% from Row 1, 28% from Row 2, 34% from Row 3 and 37% from Row 4. ANOVA showed no significant difference between any of the treatments (α = 0.05) (Table 4).

ANOVA					
Infestation					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	191.232	3	63.744	.525	.673
Within Groups	1455.967	12	121.331		
Total	1647.198	15			

Table 4 – ANOVA statistics of the average percent of clean found across four repetitions and all four treatments (α = 0.05).

Discussion

No treatments resulted in a higher mean percentage of clean raspberries than the UTC or each other. According to Michigan State University Extension, "Insecticides with fast knockdown activity have performed well at protecting berries from SWD. These include Malathion (*see note below) which is an organophosphate insecticide; the pyrethroids Asana, Danitol, Mustang Maxx, and Brigade; and the spinosyns Delegate and Entrust (organic) (Isaacs R., 2013)". Similar results to MSU extension can also be found in growing operations. So Delegate WG and Mustang Maxx 0.8EC have been proven in previous experiments to control SWD populations, but these results tell us the opposite is true.

After analysis of these results, it can be concluded that there was an inadequate application method or hidden variables that affected the efficacy of the insecticides, such as the duration of the spray timeline, the number of sprays, the spray coverage of the berries provided by the spray boom and finally, pertaining only to ECS-F-539, the adjusted application rate.

Spraying should begin once SWD has been detected in the field and continued through harvest (Isaacs R., 2013). The treatments were only applied over a three day period and no other treatments were applied to control populations before the study. This may have resulted in a high population density due to a lack of control throughout the summer and thus too much pressure from SWD to be controlled with two spray applications in less than a week. Increasing the spray duration

may yield in greater control and expected results.

Another factor that could have affected the results was the spray coverage of the raspberries. Discoloration is present, in Picture 4, where the initial rate of ECS-F-539 spray was applied. This is empirical evidence that shows coverage on the berries was less than 50%, leaving half of the berry open to oviposition. Using a different means of application, such as tractor powered air-blast sprayer instead of a hand held spray boom, will improve coverage by increasing release rate of applications and decreasing droplet size.

Separate studies should be performed to determine the rate at which control of SWD populations can be seen from ECS-F-539 on raspberries, but with no signs of phytotoxicity. The rate applied at which phytotoxicity was present was determined specifically for strawberries (Pacific Ag Research, 2016). This rate showed high repellency on strawberries in lab. This study demonstrates how the level at which phytotoxicity occurs differs across varying crops.

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References Cited

Baker R., Baufeld P., Grassi A., Guitian Castrillon J, M., Hauser M., Hueppelsheuser T., Knight J., Reynaud P., Petter F., & Sunley R. (2010). PEST RISK ANALYSIS FOR : Drosophila suzukii. Europe. Retrieved from https://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRAdocs_insects/11-17189_PRA_record_Drosophila_suzukii_final%20.pdf

Bolda M. P., Goodhue R. E., & Zalom F. G. (2010). Spotted Wing Drosophila: Potential Economic Impact of a Newly Established Pest. University of California. Retrieved from http://s.giannini.ucop.edu/uploads/giannini_public/81/fe/81feb5c9-f722-4018-85ec-64519d1bbc95/v13n3_2.pdf

Bordelon B., Cochran D., Hannan J., Jesse L. C.H., Lewis D., Johnson D., Gao G., Bergefurd B., Welty C., Beckerman J., Strang J., Wright S., Becker D., Bessin R., Gautier N.W., McManus P., Foster R. E., Weinzierl R., & Babadoost M. (2016). Midwest Fruit Pest Management Guide. 112-113. Retrieved from https://ag.purdue.edu/hla/Hort/Documents/ID-465.pdf

Isaacs R., Tritten B., Van Timmeren S., Wise J., Garcia-Salazar C., & Longstroth M. (2013, August). Spotted Wing Drosophila Management Recommendations for Michigan Raspberry and Blackberry Growers. Retrieved from http://www.treefruit.msu.edu/extension/Spotted%20Wing%20Drosophila%20fact%20sheet.pdf

Pacific Ag Research (2016). Edna Entomology Lab, Bioassay/Insecticide, Trial ID: LAS1604. 7/25/2016 - 8/1/2016. Provided by Locus Agricultural Solutions.

Pham C. K., & Ray A. (2015). Conservation of Olfactory Avoidance in Drosophila Species and Identification of Repellents for Drosophila suzukii. *Sci. Rep. 5, 11527; doi: 10.1038/srep11527*.