Title of Report
Interim Progress Report for CDFA Agreement Number 16-0511-SA

Title of Project
Insecticide Resistance in the Glassy-winged Sharpshooter: Using Historical Use Patterns to Inform Future Management Strategies

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Reporting Period
The results reported here are from work conducted July 2016 to July 2017

Introduction
This project, initiated in July 2016, is an extension of a pilot study that was conducted in 2014 and 2015 with support from the Consolidated Central Valley Table Grape Pest and Disease Control District and the CDFA Pierce's Disease Control Program. Despite continued efforts by CDFA in the Area-wide GWSS Management Program, numbers of sharpshooters had increased from 2012-2015, causing concern among the industry (Figure 1). At the same time, surveys of PD infected vines indicated an increase in disease incidence in the General Beale region of Kern County (Haviland 2015).

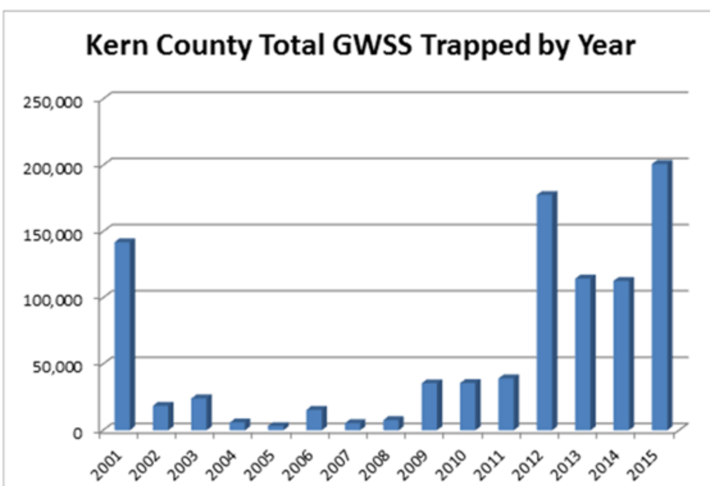


Figure 1. Total number of GWSS caught on CDFA traps in Kern Co. from 2001 – 2015. (From Haviland 2015)

In the 2015 study, we evaluated 8 commonly used compounds (Table 1), in both systemic uptake and foliar bioassays, collecting GWSS on 3 dates in July and August from an organic citrus grove in the Edison area, and 3 dates in September and October from the General Beale area. These studies showed that GWSS collected in 2015 were much less susceptible to the insecticides than they were in 2001 and 2002 (Prabhaker et al. 2006), when the Area-wide GWSS Management Program was initiated (Perring et al. 2015). For some insecticides, the studies showed LC_{50} values to be much higher in 2015, an indication of resistance in the populations. These results were similar to those obtained by Redak et al. (2015) in the same geographic region.

Table 1. Insecticides tested in adult *H. vitripennis* bioassays in 2015.

Insecticide Class	Active Ingredient	Product	Application	Manufacturer
Neonicotinoid	Imidacloprid	Admire® Pro	soil	Bayer
	Thiamethoxam	Platinum® 75 SG	soil	Syngenta
	Acetamiprid	Assail® 70 WP	foliar	United Phosphorus
Butenolide	Flupyradifurone	Sivanto™ 200 SL	foliar	Bayer
Pyrethroid	Bifenthrin	Capture® 2 EC	foliar	FMC
	Fenpropathrin	Danitol® 2.4 EC	foliar	Valent
Organophosphorus	Chlorpyrifos	Lorsban® 4E	foliar	Dow
	Dimethoate	Dimethoate® 2.67 EC	foliar	Loveland

These high levels of resistance may explain the upsurge in GWSS number in the region. At the same time, we documented variation in the relative toxicities at different times and locations throughout the 2015 season (Perring et al. 2015). In particular, there was a 79-fold increase in the LC_{50} for imidacloprid from the first bioassay of the season to the last, and there were differences in susceptibility of sharpshooters collected from different fields and geographic areas. This study suggested that toxicity was related to factors in the local context. Understanding these factors may help growers select various materials to use in their particular areas.

Objectives

1. Conduct laboratory bioassays on field-collected *H. vitripennis* from Kern County to document the levels of resistance at the beginning of the 2016 and 2017 field seasons, and to document changes in susceptibility as each season progresses.
2. Document differences in insecticide susceptibility in GWSS collected from organic vs. non-organic vineyards (grapes) and/or orchards (citrus) and from different locations in Kern County.
3. Obtain and organize historic GWSS densities and treatment records (locations, chemicals used, and timing of applications) into a Geographic Information System for use in statistical analyses.
4. Determine the relationship between insecticide susceptibility of different GWSS populations and treatment history in the same geographic location and use relationships to inform future insecticide management strategies.

Activities and Accomplishments

Objective 1

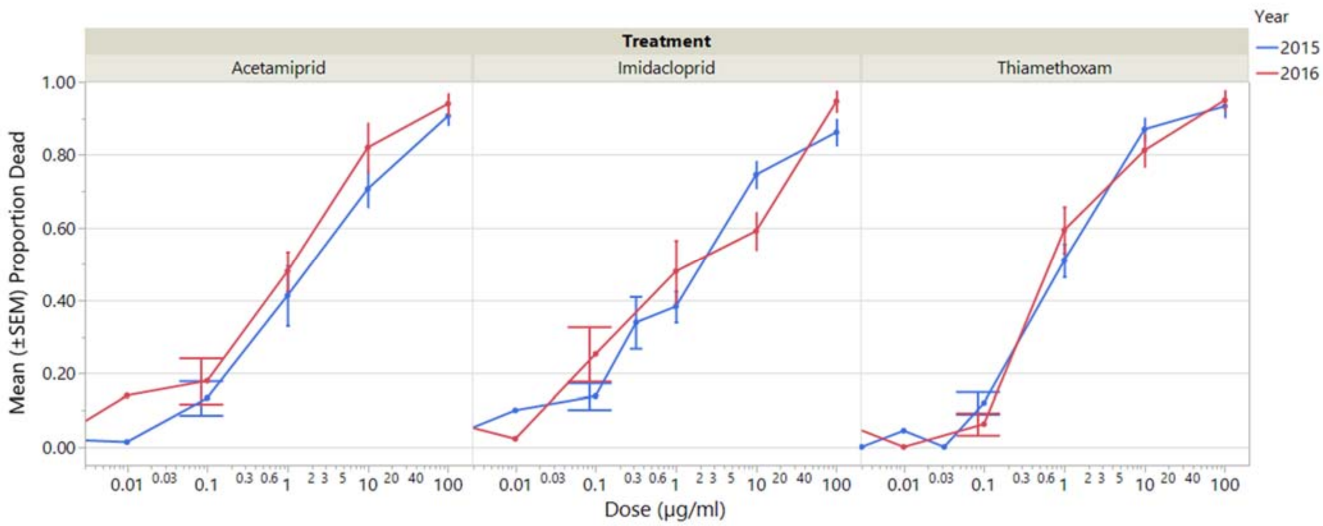
In 2016, we conducted bioassays on GWSS collected in table grapes on 26 July and 16 August, and in navel oranges on 4 October. Unfortunately, insect numbers were much lower in 2016 than in 205, thus we were limited by the number of bioassays and the number of insecticides we could test. We collected 900 adults on 26 July, sufficient for testing six insecticides (imidacloprid, thiamethoxam, acetamiprid, bifenthrin, fenpropathrin, and chlorpyrifos). From the same vineyard on 16 August, only 300 adults were collected allowing us to test only imidacloprid and thiamethoxam. On 4 October, we collected 600 GWSS, enabling tests of four insecticides (imidacloprid, thiamethoxam, acetamiprid, and bifenthrin).

When we evaluated the composite mortality curves for all three neonicotinoids from 2016 and 2015, we found relatively little difference in mortalities at various concentrations of each insecticide (Fig. 2A). The only consistent difference (although not statistically) in mortality curves was for acetamiprid, to which *H. vitripennis* test insects in 2016 were actually slightly more susceptible than those tested in 2015. Relative differences in susceptibility to either imidacloprid or thiamethoxam varied inconsistently by concentration between years. Comparison of 2015-2016 mortality curves for the pyrethroids revealed a similar pattern for each compound (Fig.

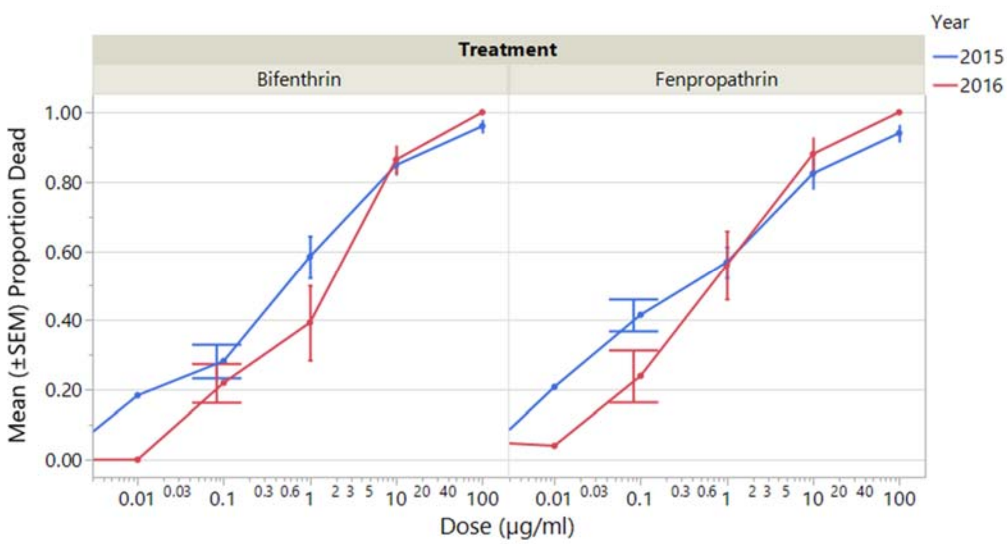
2B). Higher mortalities were observed at lower concentrations in 2015, but then crossed over at either 10 µg/ml for bifenthrin or 1 µg/ml for fenpropathrin.

Fig. 2. Composite mortality curves for (A) three neonicotinoid insecticides and (B) two pyrethroids for 2015 and 2016. From Perring et al. (2016)

A.



B.



Based on the limited numbers of insects that we had available in 2016, insecticide susceptibility appeared unchanged between 2016 and 2015. It is important to remember that the 2015 susceptibility was much lower than in 2001/2002. We have begun our studies for 2017, and have made 3 collections of GWSS, only exposing them to imidacloprid. We have decided to focus on this material, given the fact that we expect to have access to limited numbers of GWSS. It also makes sense to focus on imidacloprid since it has been used extensively in citrus (Grafton-Cardwell et al. 2008) and grapes (Daane et al. 2006). At this point, it is too early to tell the extent of susceptibility that will be present this year and how it will change through the year.

Objective 2

In order to address our second objective, we have had to refine our GIS based on 3 critical pieces of information. First, we have received the 2016 and 2017 crop coverages from Kern County and have placed them into the GIS. This allows us to identify all crop types from which GWSS may have been exposed to insecticides. Second, we have obtained the spray records from the area-wide treatment program and have created attribute layers from 2016 and 2017 treatments for each of the neonicotinoids (imidacloprid, thiamethoxam, and acetamiprid). Now we have the ability to identify fields that have been treated with any of these materials. Third, we have gained access to the GWSS trap data that are being collected by the CDFA GWSS trapping program. We are able to see the trap counts as they are updated from the trappers, allowing us a real-time assessment of where GWSS densities are highest. These high trap sites are manually placed into our GIS, which give us sampling sites that are physically close to fields that have been treated this year. At the same time, we can select sites that are not close to treated sites. By conducting bioassays on GWSS collected from treated and non-treated sites, we can determine if recent insecticide treatments have had an influence on the level of susceptibility in the population at that site.

Objectives 3 and 4

Our GIS now has the crop coverages and we are creating attribute layers for the neonicotinoid sprays for each year since the area-wide program was initiated. To date we have 2016 and 2017 data in the GIS and we continue to work on previous years. At the same time we are working to input the GWSS trap data from the past 16 years. This has turned out to be more difficult than we anticipated, because the trap data from the thousands of traps that have been counted every 2 weeks do not reside in a GIS database format. Thus we are determining the best way to analyze the data so that we can gain an understanding of how spray sites may have impacted subsequent number of GWSS near those sites.

Publications and Presentations

Publications

Perring, T.M., Prabhaker, N., Castle, S., Haviland, D., Stone-Smith, B. 2016. Monitoring for insecticide resistance in the glassy-winged sharpshooter Homalodisca vitripennis (Germar) (Hemiptera: Cicadellidae) in California. Pp. 221-229 In T. Esser (Ed.) Proceedings, 2016 Pierce's Disease Research Symposium. California Department of Food and Agriculture, Sacramento, CA.

Presentations

Perring, T.M., Prabhaker, N., Castle, S., Haviland, D., Stone-Smith, B. 2016. Insecticide resistance in GWSS: Using Historical Use Patterns for Future Management. Oral presentation (plenary session). 2016 Pierce's Disease Research Symposium, Sacramento, CA. 13 December, 2016.

Perring, T.M., Prabhaker, N., Castle, S., Haviland, D., Stone-Smith, B. 2016. Monitoring for GWSS Insecticide Resistance in California. Poster Presentation. 2016 Pierce's Disease Research Symposium, Sacramento, CA. 13 December, 2016.

Research Relevance Statement

Studies conducted in 2015 showed that GWSS were less susceptible to insecticides commonly being used to control it than they were in 2001 and 2002. Of particular concern was that the LC_{50} values for imidacloprid, bifenthrin, and fenpropathrin increased as the 2015 growing season progressed. Subsequent bioassays conducted in 2016 found the susceptibility to imidacloprid was well within the range, or lower than LC_{50}s observed in 2015. Yet it was still higher than the LC_{50} values from 2001/2002. Current studies are focusing on uptake bioassays with imidacloprid, because this chemical has had the most consistent usage in citrus and grapes since the beginning of the area-wide GWSS control program. Our goal is to understand if there is a link between resistance levels and recent usage of imidacloprid and other neonicotinoid products (thiamethoxam and acetamiprid). If so, this may inform the selection of chemicals in the future.

Layperson Summary

Insecticides are key to the management of Pierce's Disease, through their reducing impact on GWSS numbers. High insect numbers from 2012-2015, despite continued monitoring and treatment suggested a change in the susceptibility to commonly used products. Our studies in 2015 showed high levels of resistance to insecticides in Kern County populations of GWSS, with declining susceptibility as the season progressed. Fortunately there was no further reduction in susceptibility in 2016, but the levels of susceptibility were still much lower than in 2000-2001 when the area-wide GWSS program was initiated. We have started our 2017 program, focusing solely on imidacloprid, the insecticide that has been used most frequently in citrus and grapes. By selecting treated and non-treated (organic) fields and sampling GWSS at fields of each type, we will be able to link resistance levels to recent insecticide use. Should a strong relationship be shown, it will inform the selection of future insecticides for GWSS control.

Status of Funds
This is a two year project that was initiated in July 2016. Funding expenditures are appropriate for the current place in the grant cycle.

Summary and Status of Intellectual Property
Aside from the published proceedings and the presentation at the CDFA PD conference, no intellectual property was produced as a result of this research project.

Literature Cited

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