Title of Report

Renewal Progress Report for CDFA Agreement Number 14-0381-SA.

Title of Project

Monitoring for insecticide resistance in the glassy-winged sharpshooter *Homalodisca vitripennis* (Germar) (Hemiptera: Cicadellidae) in California.

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Reporting Period

The results reported here are from work conducted July 2015-June 2015

Introduction

Area-wide programs administered by USDA-APHIS for *H. vitripennis* control first were implemented in 2000 and have been an integral part of its management ever since. Well-timed applications of imidacloprid in citrus orchards have proven to be highly effective at reducing the first generation of *H. vitripennis* each year and limiting the dispersal out of citrus to grapes and other crops vulnerable to transmission of *Xylella fastidiosa* (Castle et al. 2005). In addition, abatement programs conducted at the state and county levels have caused wide exposure of *H. vitripennis* populations to a number of foliar insecticides representing different classes and modes of action. These programs have been driven by intense concerns about the capacity of *H. vitripennis* to increase to conspicuous numbers and disperse across the landscape spreading *X. fastidiosa*. The outfall from such concerns has been a prolonged exposure of *H. vitripennis* populations to multiple classes of insecticides over a wide area of California for more than a decade. The legacy of insecticide resistance occurrence in over 500 species of arthropods (http://www.pesticideresistance.com/) has been that continuous exposure of insect populations to insecticide treatments eventually results in some level of resistance to one or more insecticides. Whether this phenomenon is responsible for control problems that have been reported in Kern Co. is unknown and will remain so without appropriate toxicological investigations. Successful management of insecticide resistance requires monitoring of populations to test their relative susceptibility to various insecticides and making appropriate adjustments in the insecticide regimen to reduce insecticide resistance selection pressure. Information gained by a resistance monitoring program on specific insecticides that are no longer effective is essential to a sustainable management program for *H. vitripennis*.

At the time that concerted action first was mobilized to address the threat represented by the spread of *H. vitripennis* in California, virtually no field efficacy data or toxicological information was available regarding relative susceptibilities to various insecticides. What soon became clear from research investigations as well as area-wide and local community control actions was that *H. vitripennis* populations responded readily to insecticide treatments. Dramatic declines were observed in the area-wide control programs, and locally heavy infestations could be knocked down by a single treatment compared to other agricultural pests that continue to persist at economically high densities no matter what treatment is applied. For example, systemic uptake bioassays with imidacloprid produced LC_{50}s of 16 and 22 ng ml^{-1} (= parts per billion) in two different tests using *H. vitripennis* adults collected from citrus at UC Riverside's Ag Ops. In comparison, the same type of bioassay performed on field populations of the silverleaf whitefly, *Bemisia argentifolii*, typically yielded LC_{50}s in the range of 3-115 µg ml^{-1} (e.g. Prabhaker et al. 2005), values approximately 1,000 times greater than those for *H. vitripennis*. In the case of another compound widely used for *H. vitripennis* control, the LC_{50} for chlorpyrifos was determined at 3.4 ng ml^{-1} (Prabhaker et al. 2006), whereas LC_{50}s against *B. argentifolii* for chlorpyrifos often requires 1,000-2,000 µg ml^{-1} (Castle et al. 2009), a concentration nearly one million times greater than that needed to produce the same level of mortality in a bioassay for *H. vitripennis*. Remarkably, commercial rates for chlorpyrifos (Lorsban® 4E) have been in the neighborhood of 12 pts $acre^{-1}$ (formulated product) (Grafton-Cardwell 2003), the top label rate for this insecticide in citrus. At rates this high, the likelihood of potential overkill of both *H. vitripennis* and beneficial insects is high. Unfortunately, toxicological data that puts into perspective the relative susceptibility of *H. vitripennis* have not been available when determining what rates to use for combating *H. vitripennis* infestations. Awareness of such information along with other field-based efficacy data is crucial to the development and deployment of an evidence-based insecticide use strategy.

Previous studies by the members of this research team have demonstrated the high susceptibility of *H. vitripennis* to insecticides and the contributions of natural enemies to the control of *H. vitripennis* populations (Castle et al. 2005 a,b; Prabhaker et al. 2006 a,b, 2007). However, toxicological tests for these studies were carried out relatively early within the time period that area-wide and local control efforts were carried out against *H. vitripennis*. To our knowledge, there have been no subsequent studies on susceptibility of *H. vitripennis* populations to insecticides even though insecticides have served as the primary defense against *H.vitripennis* populations. Because pesticides are an integral part of the high-yielding production agriculture in citrus and grapes, pest resistance to pesticides must be evaluated. This potential is magnified when overreliance on a few select products occurs, such as has been the case with the use of imidacloprid in the area-wide control programs and by growers and pest control advisors protecting their orchards and vineyards. The repeated use of the same product(s) for control of a pest population results in continual selection pressure, which ultimately may result in resistance development. The continued successful implementation of insecticides in management programs require that their efficacy be carefully evaluated and monitored to ensure maximum benefit. Insecticide resistance poses the most serious threat to the long-term use of insecticides for controlling *H. vitripennis*. There are both financial and environmental costs associated with resistant populations that can be mitigated by a resistance monitoring and management program.

List of Objectives

1. Conduct laboratory bioassays on field-collected *H. vitripennis* from Kern and Tulare Counties to determine susceptibility to neonicotinoid, pyrethroid, and organophosphate insecticides.
2. Investigate the geographic variation in susceptibility of *H. vitripennis* to determine if a pattern of resistance emerges associated with insecticide use patterns.
3. Identify potential resistance evolution of the field populations of GWSS to insecticides by comparing the LC_{50} values to previously established LC_{50}s using the same methodology.
4. Evaluate relative toxicity of new insecticides such as spirotetramat, cyantraniliprole, and flupyradifurone as candidates for alternative treatments for *H. vitripennis*.

Activities and Accomplishments

Objectives 1 and 2

Collections of *H. vitripennis* were made from the Bena Road area east of Bakersfield in July, August and September. A mixed age navel orange orchard yielded high numbers of adults the first two months, but then was treated by insecticides in September that virtually eliminated the once heavy infestation. An organic navel orange orchard was sampled for the September collection that also returned a high number of adults for bioassay purposes. In the Temecula region, *H. vitripennis* adults were collected from organic citrus orchards but they were in much lower densities compared to the Bakersfield locations. Thus they required considerably more time before sufficient numbers were obtained for bioassay tests.

Differences in toxicities among insecticides were observed in the August and September collections from Kern Co. A comparison between the two neonicotinoids, dinotefuran (Venom®) and imidacloprid (Admire® Pro), indicated the higher toxicity of dinotefuran (Figure 1). However, a progressive dose response at relatively low concentrations was still observed with the imidacloprid treated insects that suggests susceptibility to imidacloprid is still present in this population. A similar dose response was observed in *H. vitripennis* collected from Temecula (Figure 2). High control mortality was observed with Temecula insects as well as in other bioassays that will have to be corrected by improving handling of insects in future tests.

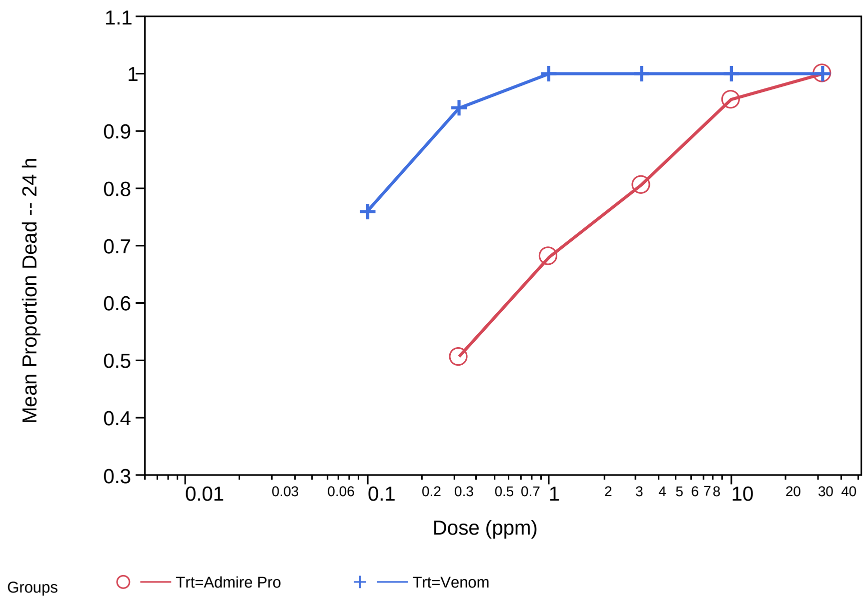

Figure 1. A comparison of mortality responses in *H. vitripennis* from Kern Co. to the neonicotinoid insecticides dinotefuran and imidacloprid.

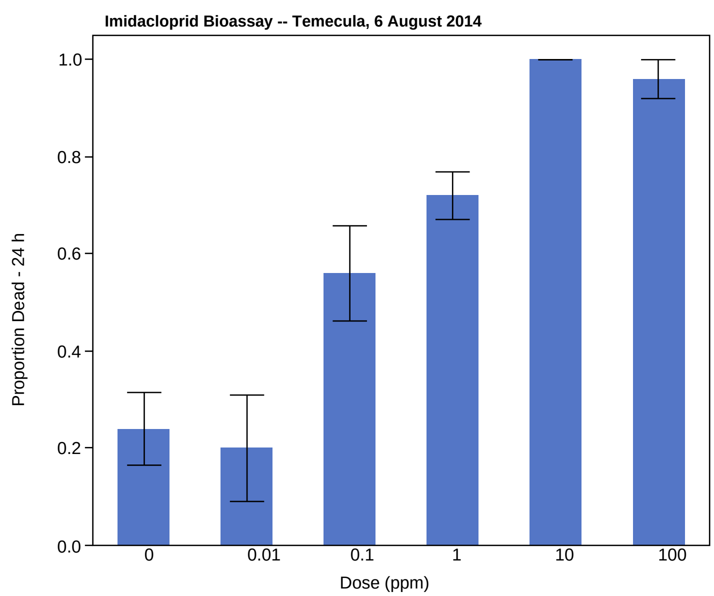

Figure 2. Mortality response to imidacloprid in *H. vitripennis* collected from Temecula. The approximate 70% mortality at 1.0 ppm is similar to the mortality seen in Kern Co. insects at the same dose (see Figure 1).

In addition to the neonicotinoids, two pyrethroid insecticides also showed extreme toxicity against *H. vitripennis* (Fig. 3). The concentration range was clearly set too high and will have to be adjusted lower for future testing. Of the two insecticides, bifenthrin appeared more toxic than fenpropathrin. Based on the toxicity observed in the bioassay, it seems possible that either insecticide could serve as an effective knockdown agent in situations where an infestation needed to be brought quickly under control.

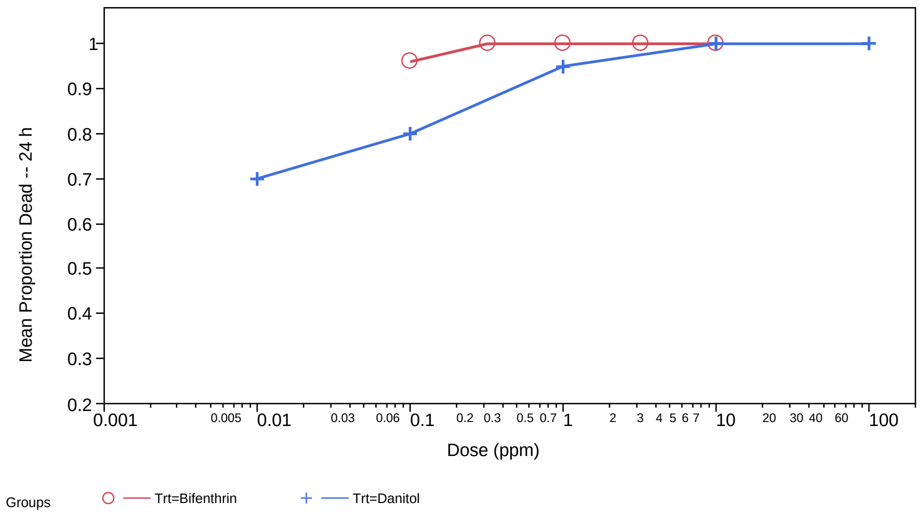

Figure 3. Comparison of mortality responses in *H. vitripennis* adults to bifenthrin (Capture®) and fenpropathrin (Danitol®).

<u>Publications and Presentations</u>

<u>Publications</u>

Perring, T. M., N. Prabhaker, S.J. Castle. 2014. Monitoring for insecticide resistance in the glassy-winged sharpshooter in California. Pp. 31 - 35 *In* T. Esser (ed.) Proceedings, 2014 Pierce's Disease Research Symposium. California Department of Food and Agriculture, Sacramento, CA.

<u>Presentations</u>

Perring, T. M., 2014. Monitoring for insecticide resistance in the glassy-winged sharpshooter in California. Oral presentation (plenary session). 2014 Pierce's Disease Research Symposium, Sacramento, CA. 16 December, 2014.

Perring, T. M., N. Prabhaker, and S.J. Castle. 2014. Monitoring for insecticide resistance in California. Poster presentation. 2014 Pierce's Disease Research Symposium, Sacramento, CA. 16 December, 2014.

Castle, S.J., T.M. Perring, and N. Prabhaker. 2015. Monitoring for insecticide resistance in the glassy-winged sharpshooter in California. Oral presentation to the Kern/Tulare Consolidated Table Grape Commission, 2 April, 2015.

<u>Research Relevance Statement</u>

Growers in the General Beale region of Kern County have experienced an increase in GWSS densities over the past few years, despite the continued applications of imidacloprid to citrus in the area. At the request of the Kern/Tulare Consolidated Table Grape District, we initiated a program determine whether resistance in the GWSS was responsible for this increase. We conducted bioassays on *Homalodisca vitripennis* populations collected in Kern and Riverside Counties from July through September 2014. Mortality responses were high to imidacloprid and to a second neonicotinoid compound, dinotefuran. Other compounds tested included two pyrethroids, bifenthrin and fenpropathrin, and two organophosphates, chlorpyrifos and dimethoate. Of these six insecticides, only dimethoate failed to elicit a strong mortality response. Comparison of 2014 bioassay results to test results obtained from 2001-2003 suggest that no significant change in responsiveness to insecticide treatments has occurred in *Homalodisca vitripennis* populations from either region.

Layperson Summary

Management of *H. vitripennis* in California for more than a decade has relied heavily on insecticide treatments to suppress populations and ultimately reduce vector pressure and incidence of Pierce's disease. The neonicotinoid insecticide imidacloprid has played a pivotal role in area-wide control programs in Kern and Riverside counties where a mix of citrus and grapes acreages contributed in the past to high populations of *H. vitripennis* and epidemics of Pierce's disease. Reports in recent years about increased numbers of *H. vitripennis* occurring in Kern County despite area-wide applications of imidacloprid have raised concerns about the possibility of resistance to imidacloprid being present in *H. vitripennis* populations. The present study was undertaken to investigate responses of *H. vitripennis* populations to imidacloprid and other insecticides in bioassays conducted in the laboratory using field-collected samples. Comparison of bioassay results from 2014 collections to similar results obtained from 2001-2003 indicate non-significant differences in susceptibilities. Further testing from additional sites in Kern and Riverside counties will be necessary before conclusively determining whether *H. vitripennis* populations have developed resistance to one or more insecticides.

Status of Funds

This is a two year project that was split between the CDFA PD/GWSS Board and the Consolidated Central Valley Table Grape Pest and Disease Control District. Funds for the first year have been expended.

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

Castle, S. J., Byrne, F. J., Bi, J. L., and Toscano, N. C. 2005a. Spatial and temporal distribution of imidacloprid and thiamethoxam in citrus and impact on *Homalodisca coagulata* populations. Pest Manage. Sci. 61: 75-84.

Castle, S. J., Naranjo, S. N., Bi, J. L., Byrne, F. J., and Toscano, N. C. 2005b. Phenology and demography of *Homalodisca coagulata* in southern California citrus and implications for management. Bull. Entomol. Res. 95, 621-634.

Castle S.J., Prabhaker N., Henneberry T.J. & Toscano N.C. 2009. Host plant influences on susceptibility of *Bemisia tabaci* (Hemiptera: Aleyrodidae) to insecticides. Bull. Entomol. Res. 99: 263-273.

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Acknowledgements

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