LINKING WITHIN-VINEYARD SHARPSHOOTER MANAGEMENT TO PIERCE'S DISEASE SPREAD

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Objectives and activities to accomplish objectives

Chemical control of insect vectors plays a crucial role in many disease mitigation programs. This is true not only for the management of mosquito-borne diseases of humans, such as malaria and dengue fever, but also for limiting disease epidemics in a wide range of agricultural crops. In southern California vineyards chemical control at both the area-wide and local scales may affect the severity of Pierce's disease, by reducing the density or activity of the primary vector, the glassy-winged sharpshooter (*Homalodisca vitripennis*; Castle et al. 2005).

The bacterial pathogen *Xylella fastidiosa* is endemic to the Americas, and is widespread throughout the western and southeastern U.S. This xylem-limited bacterium is pathogenic to a wide variety of plants, including several important crop, native, ornamental, and weedy species (Purcell 1997). In the Western U.S. the most economically significant host is grapevine, in which *X. fastidiosa* causes Pierce's disease. Multiplication of the bacterium in vines plugs xylem vessels, which precipitates leaf scorch symptoms and typically kills susceptible vines within a few years (Purcell 1997).

X. fastidiosa can be spread by several species of xylem sap-feeding insects, the most important being the sharpshooter leafhoppers (Severin 1949). Historically Pierce's disease prevalence has been moderate, with a pattern that is consistent with primary spread into vineyards from adjacent riparian habitats by the native blue-green sharpshooter (*Graphocephala atropunctata*). However, beginning in the late 1990s severe outbreaks occurred in southern California and the southern San Joaquin Valley that are attributable to the recent establishment of the glassy-winged sharpshooter. This invasive sharpshooter is not inherently more efficient at transmitting the pathogen than are native sharpshooters (Almeida and Purcell 2003). Instead its threat as a vector appears to stem from a combination of ability to achieve extremely high densities (Blua et al. 1999) and promote vine-to-vine (i.e. secondary) disease spread (Almeida et al. 2005).

Citrus trees themselves are not susceptible to the strains of *X. fastidiosa* found in the U.S. (though strains found in Brazil have caused significant economic losses to their citrus industry – Purcell 1997). None-the-less citrus plantings figure prominently in the epidemiology of *Xylella* diseases in California. Many portions of southern California and the southern San Joaquin Valley have vineyards in close proximity to citrus groves (Sisterson et al. 2008). This is important because citrus is a preferred habitat for the glassy-winged sharpshooter at key times of the year, allowing this vector to achieve very high densities (Blua et al. 2001). High vector populations then disperse seasonally out of citrus into nearby vineyards, resulting in clear gradients of Pierce's disease prevalence (i.e. proportion of infected plants) as a function of proximity to citrus (Perring et al. 2001).

Given the importance of citrus in Pierce's disease epidemiology, citrus groves have been the focus of area-wide chemical control programs, initiated in the Temecula and Coachella Valleys in the early 2000s and shortly afterward in Kern and Tulare Counties (Sisterson et al. 2008). The southern California programs use targeted application of systemic insecticides, such as imidacloprid, to limit *H. vitripennis* populations residing within citrus. Census data in citrus show substantial year to year variation in sharpshooter abundance that may stem from incomplete application, the use of less effect organically-derived insecticides, or inadequate irrigation to facilitate uptake - which makes the consistent management of sharpshooter populations a challenge (Toscano and Gispert 2009). None-the-less trap counts have been, overall, much reduced compared to pre-area-wide counts. The effect of chemical control can be seen clearly in early insect surveys which found significantly fewer sharpshooters in treated relative to untreated citrus and in vineyards bordering treated versus untreated groves (R. Redak and N. Toscano, unpublished data). Thus, these area-wide control programs have been considered successful in southern California (Toscano and Gispert 2009), and the swift implementation of an area-wide management program in Kern County has been credited with limiting the severity of Pierce's disease outbreaks (Sisterson et al. 2008).

Research into imidacloprid uptake by grape also has been initiated, and target concentrations high enough to suppress glassy-winged sharpshooter activity (approx. 10 μg/L of xylem sap) can be achieved and will endure for several weeks in mature vines (Byrne and Toscano 2006). This information coupled with the success of area-wide programs in citrus appears to have led to relatively widespread adoption by grape growers of imidacloprid application in vineyards to reduce further exposure to *X. fastidiosa*. In Temecula Valley, for example, it is estimated that 70% of vineyards use imidacloprid, at an approximate cost of $150-200 per acre (N. Toscano, personal communication). Yet consistent treatment of vineyards with systemic insecticides is neither universal, nor have there been any measures of how effective these costly treatments are at reducing Pierce's disease incidence.

We are studying the epidemiological significance of chemical control in vineyards, via a multi-year series of field surveys in Temecula Valley. This work will address gaps in empirically-derived observations regarding the cascading effects of vineyard imidacloprid applications on glassy-winged sharpshooter abundance and, ultimately, Pierce's disease severity.

The overall goal of this project is to understand **does within-vineyard sharpshooter chemical control reduce vector pressure and Pierce's disease spread?** This goal includes the following two specific objectives:

1. *Link within-vineyard sharpshooter management to Pierce's disease prevalence*.
2. *Quantify the form of disease progression – primary versus secondary spread*

This project was initiated last summer. We completed the first of three seasons of Fall disease surveys. Over the next two additional seasons we will continue these surveys and collect additional data on vector abundance, imidacloprid concentrations, and *X. fastidiosa* genotype distribution in order to address these two objectives.

In the Fall of 2009 we conducted a pilot survey of some Temecula vineyards. These surveys relied on visual Pierce's disease symptoms for 5 pairs of regularly treated and untreated vineyards, plus a 6th unpaired treated vineyard. For each vineyard we visually inspected all vines in each of the vineyards in October and November and scored the proportion of vines showing any symptoms of Pierce's disease.

In the Fall of 2010 we began the first of three consecutive years of surveys in a set of vineyards. In order to identify vineyards with known imidacloprid treatment histories for use in the surveys we interviewed several vineyard owners and vineyard managers in the Temecula region. From these interviews we acquired information on 88 distinct properties in the area. This information was used to bin vineyards into one of three treatment groups: regularly treated (i.e., yearly over at least the last 5 years), mixed treatment history (i.e., one or more years of treatment in the last 5 years), and untreated (i.e. no chemical control or organic applications). From late September through early November we surveyed 34 of these vineyards: 13 treated, 12 mixed, and 9 untreated (Fig. 1). As in the pilot study we visually inspected all vines for pierce's disease. In addition we collected petiole samples from up to 50 randomly selected symptomatic vines that were later plate cultured to determine the proportion of symptomatic vines that were infected with *X. fastidiosa*. We also collected petioles from up to 100 randomly selected asymptomatic vines. This second group of samples is currently being analyzed to determine the frequency of latent (i.e. non-symptomatic) infections in each vineyard, which will be used as a correction factor for the prevalence estimates based on visual symptoms and culturing. Finally, we have deployed sticky traps in each of the 34 vineyards that will be checked regularly for *H. vitripennis.*

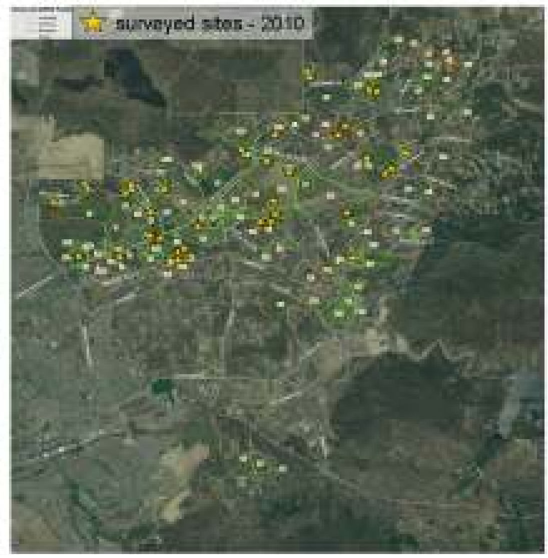

Figure 1. Location of the 34 sites used in the Temecula Valley disease surveys.

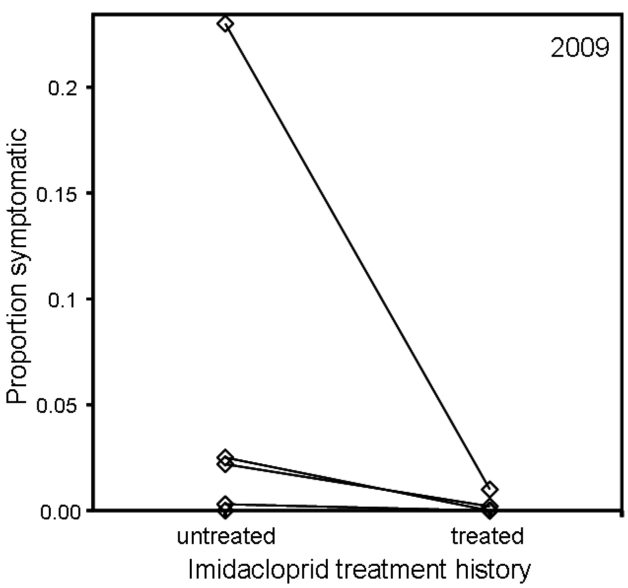

Figure 2. Proportion of plants displaying Pierce's disease symptoms in pairs of imidicloprid treated or untreated vineyards. Observations from Temecula Valley pilot surveys, Fall 2009. Lines connect untreated vineyard with a treated neighboring field.

Research accomplishments and results

In the Fall of 2009 pilot surveys disease prevalence varied greatly among fields, ranging from 0 to 22%, with lower overall prevalence in treated compared to untreated fields (Fig. 2). For all 5 pairs, the untreated field had equal or higher (by up to

20%) prevalence, with 4 of the 6 treated fields having no apparent infected vines.

Of the 88 distinct properties for which we acquired information in the 2010 interviews 66 were treated regularly with imidacloprid, 14 were treated intermittently, and 8 properties were not treated with imidacloprid for at least the last 4 years. Thus imidacloprid treatment is a commonly employed strategy for managing sharpshooter populations in the region.

In the first of three years of surveys, made in Fall 2010, we observed similar disease prevalence patterns as in the pilot surveys. Although Pierce's disease prevalence varies greatly among vineyards, those that were treated consistently with systemic insecticide or which had mixed treatment histories tended to have lower prevalence on average, based on visual symptoms alone, than fields that were untreated (Fig. 3a). However it is important to note that several of the untreated vineyards had very low disease prevalence, presumably because of either low vector pressure within the last few years or efforts to remove disease vines. It is also interesting that prevalence in the mixed treatment fields was equal to or lower than the regularly treated fields. These same relative patterns remain after correcting for any false positive estimates from field surveys, using plate cultured samples (Fig. 3b).

Thus, results so far suggest that within-vineyard sharpshooter chemical control may be effective at reducing disease pressure. However these results should be viewed as preliminary. More complete surveys are needed to estimate the effect of chemical control on vector abundance in vineyards and year-to-year increases in disease (i.e. incidence).

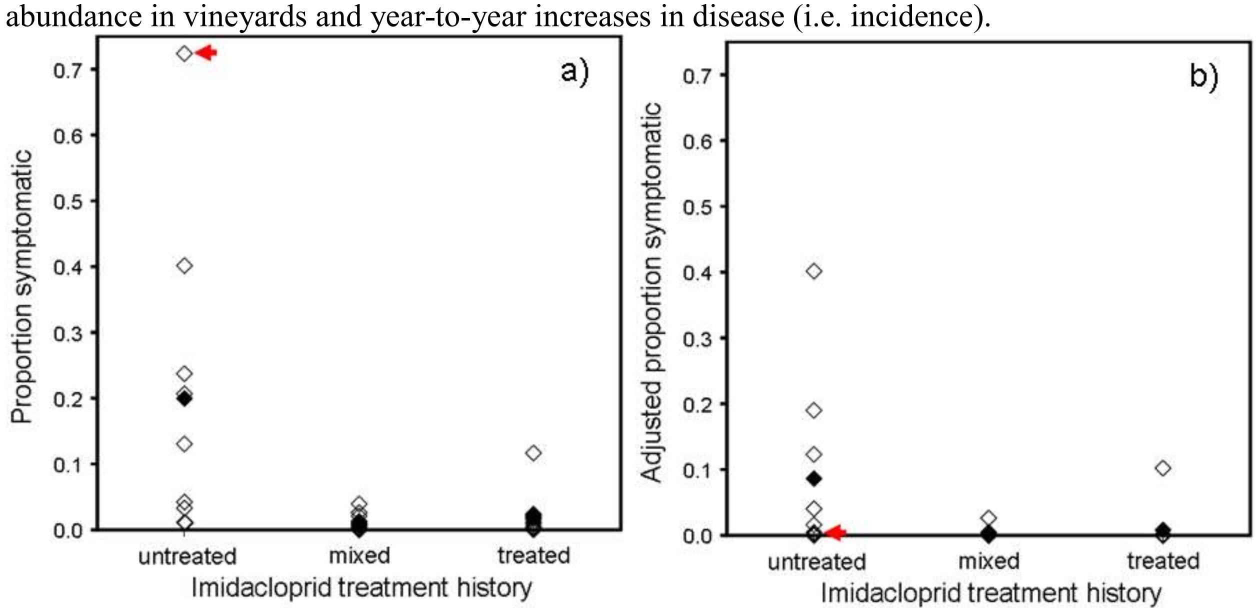

Figure 3. a) proportion of plants displaying Pierce's disease symptoms in treated, mix treated, or untreated vineyards. b) proportion with disease after adjusting for false positives. Observations from Temecula Valley, 2010.

Publications and reports

Daugherty, M.P., and T. Pinckard. 2010. Linking within-vineyard sharpshooter management to Pierce's disease spread. California Department of Food & Agriculture. p.235-237. 2010 Pierce's Disease Research Symposium. Pierce's Disease Control Program.

Presentations on research

Daugherty, M.P., et al. 2010. Vector Management and Pierce's Disease Epidemiology in Southern California. California Department of Food & Agriculture. 2010 Pierce's Disease Research Symposium. San Diego, CA

Daugherty, M.P., et al. 2011. How important is vine-to-vine spread? Research report to the Consolidated Central Valley Table Grape Pest and Disease Control District. Delano, CA.

Research relevance

Pierce's disease management in southern California vineyards hinges on chemical control of populations of the vector, the invasive glassy-winged sharpshooter (*Homalodisca vitripennis*), residing in citrus. Yet the effectiveness of chemical control programs at reducing Pierce's disease spread has not been documented. We are conducting a series of surveys in treated and untreated vineyards in Temecula Valley to determine the relative economic value of within-vineyard chemical control for Pierces disease management. These surveys will be conducted over three consecutive years to evaluate the relative importance of vector pressure and chemical control for disease spread. Ultimately, survey data will be used to quantify rates of secondary spread and the spatial distribution of *Xylella fastidiosa* strains, which is needed for drawing inferences regarding sharpshooter movement and pathogen sources.

Lay summary

One of the main tools for dealing with the glassy-winged sharpshooter in southern California and the southern San Joaquin vineyards is the application of insecticides. Systemic insecticides (imidacloprid) are regularly applied to citrus, which is a preferred plant type for sharpshooter, to reduce insect abundance before they move into vineyards. These treatment programs have been successful, reducing sharpshooter populations to a fraction of what they once were. Grape growers frequently use systemic insecticides in vineyards as well to reduce further the threat of sharpshooters spreading Pierce's disease among vines. However, no measurements have been made about whether these costly insecticide treatments are effective at curbing disease spread. We are conducting a series of disease surveys in Temecula Valley to understand whether chemical control of glassy-winged sharpshooter in vineyards is justified. Results from preliminary surveys indicate that the frequency of disease in vineyards varies greatly, but generally fields that are treated regularly or even intermittently tend to have fewer diseased vines than those that are not treated with imadacloprid. We will continue these disease surveys over the next few years to more fully evaluate this question.

Status of funds

Currently, the progress we have made on the project matches up with the proposed timeline. Remaining funds are fully committed towards completing the required project tasks, therefore we expect to exhaust these funds in the same timeframe as originally budgeted.

Intellectual property

N/A

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