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

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ABSTRACT
Pierce's disease (PD) management in southern California vineyards hinges on chemical control of populations of the vector, the invasive glassy-winged sharpshooter (GWSS), residing in citrus. Growers also frequently apply systemic insecticides in vineyards, but the efficacy of these treatments for disease management is not known. 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 PD management. In each of the past two seasons we have surveyed 34 vineyards in the Temecula Valley that differ in their use of systemic insecticides. In 2011, as in 2010, vineyards that either consistently or irregularly applied imidacloprid to vines had similarly low PD prevalence. Prevalence was more variable in those vineyards that have not treated with systemic insecticides, with several vineyards having nearly no diseased vines but also two vineyards that showed more than 5% disease. These surveys will continue for a final season, after which we will use changes in prevalence among years and estimates of GWSS abundance to estimate rates of pathogen 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.

LAYPERSON SUMMARY
One of the main tools for dealing with the glassy-winged sharpshooter (GWSS) 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 GWSS, 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 (PD) 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 GWSS in vineyards is justified. Results thus far indicate that on average vineyards that employ systemic insecticides tend to have low PD prevalence. Yet, given that some of the untreated or intermittently treated fields had extremely low prevalence, it is plausible that systemic insecticides may not need to be applied every year – at least for sites or years with low vector pressure. We will continue these disease surveys for a final year, and then calculate overall estimates of disease spread in the region.

INTRODUCTION
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 (PD), by reducing the density or activity of the primary vector, the glassy-winged sharpshooter (GWSS; *Homalodisca vitripennis*; Castle et al. 2005).

The bacterial pathogen *Xylella fastidiosa (Xf)* 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 *Xf* causes PD. 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).

Xf can be spread by several species of xylem sap-feeding insects, the most important being the sharpshooter leafhoppers (Severin 1949). Historically PD 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 *Xf* 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 PD prevalence (i.e. proportion of infected plants) as a function of proximity to citrus (Perring et al. 2001).

Given the importance of citrus in PD 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 GWSS 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 PD outbreaks (Sisterson et al. 2008).

Research into imidacloprid uptake by grape also has been initiated, and target concentrations high enough to suppress GWSS 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 *Xf*. 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 PD 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, PD severity.

OBJECTIVES

1. Understand if within-vineyard sharpshooter chemical control reduces vector pressure and PD spread.

We are currently in the middle of the second of three seasons of fall disease surveys. Next year we will conduct the final season of surveys, then use the three years of disease prevalence estimates, vector abundance, imidacloprid concentrations, and *Xf* genotype distribution to draw inferences regarding the relative rates of pathogen spread in fields differing in management tactics.

RESULTS AND DISCUSSION

Last summer we interviewed several vineyard owners and vineyard managers in the Temecula region to identify vineyards with a range of imidacloprid treatment histories. This season we collected leaf samples from all 34 vineyards included in the study (**Figure 1**), based on those interviews, to verify that our information regarding imidacloprid treatment history was accurate. Those samples are currently being processed.

Beginning in February 2011 we deployed yellow-sticky traps in each of the vineyards to monitor GWSS populations. The traps were collected monthly, GWSS and generalist predators were counted, then new traps were deployed. This monitoring data is still being collated. June sharpshooter counts up through June were very low, with no obvious difference in catches between vineyards differing in chemical control strategy.

Like last year, we again surveyed PD prevalence in the 34 vineyards. This work is ongoing. Thus far the estimates based only on visual symptoms have been completed (**Figure 2**). The results suggest that there is substantial variability in disease prevalence among sites. Sites treated every year or irregularly with systemic insecticide had similarly low apparent disease prevalence based on visual scores (1.1% and 1.5%, respectively). On average, sites that were not treated with imidacloprid for at least several years had higher prevalence (2.6%), but with a large range from just 0.5% to nearly 7%. Given the potential for misidentification of disease status based on visual surveys we collected up to 50 putatively symptomatic samples from each vineyard to be cultured for the presence of *Xf*. In addition we collected 100 asymptomatic samples from each vineyard to be tested for latent infection using ELISA. These asymptomatic and symptomatic samples are currently being processed, the results of which will be used to refine the estimate of disease prevalence based on symptoms alone.

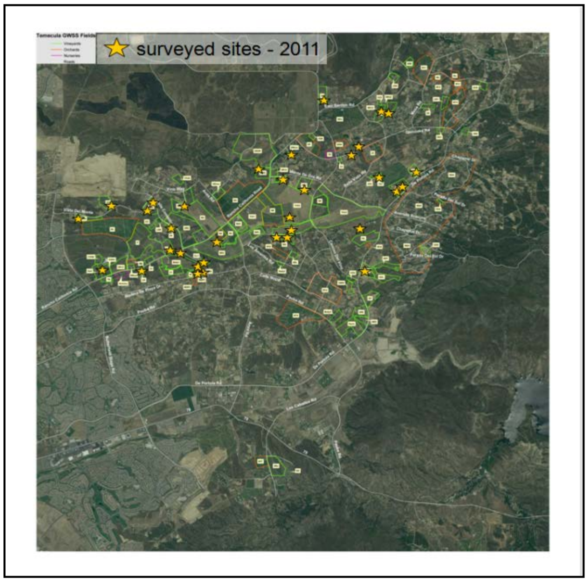

Figure 1. Field sites included in the 2010 and 2011 Pierce's disease surveys. Collectively the sites represent 34 separate vineyard blocks that have been untreated (n=9), intermittently treated (n=12), or regularly treated (n=13) with imidacloprid.

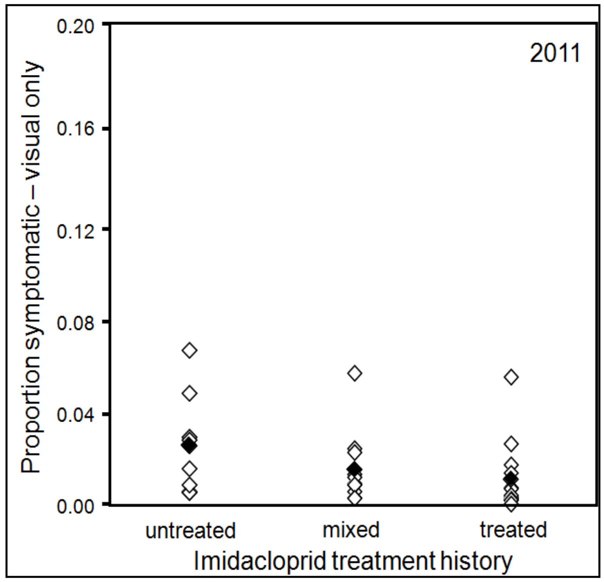

Figure 2. Proportion of vines with Pierce's disease symptoms in fields with different insecticide treatment histories. Observations from preliminary 2011 surveys in Temecula Valley based on putative symptoms alone. Some points overlap (n=9, 12, 13 for Untreated, Mixed and Treated respectively). Filled symbols represent means.

CONCLUSIONS

Results so far suggest that current PD prevalence throughout the Temecula Valley region is low. There is a trend for differences in prevalence based on chemical control strategies, with untreated vineyards having the highest average prevalence, but whether those differences are due to recent management, historical artifacts, or differences in vector pressure remains unclear. Ultimately estimates of year-to-year changes in prevalence are needed (i.e. incidence), which are ongoing, to determine the precise impact of within-vineyard systemic insecticides on disease spread.

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