

# Spatial Monitoring and Detection of Pierce's Disease of Grapevines and Bacterial Leaf Scorch of Shade Trees

Yong-Lak Park<sup>1</sup>, John Baniecki<sup>1</sup>, Essam Dabaan<sup>1</sup>, Thomas Perring<sup>2</sup>, and Rayda Krell<sup>2</sup>

<sup>1</sup>, Division of Plant and Soil Sciences, West Virginia University, Morgantown, WV <sup>2</sup>, Department of Entomology, University of California, Riverside, CA

## INTRODUCTION

A key component in the development of a management program for *Xylella fastidiosa*-induced plant diseases (e.g. Pierce's disease of grapevine and bacterial leaf scorch of shade trees) is determining the location of infected plants. Without this knowledge, it is impossible to understand how *Xylella fastidiosa* is spread by insect vectors or how features of the environment surrounding diseased plants impact movement of *X. fastidiosa* through the area. Even the most basic short term management practice of removing infected plants becomes an abstract thought if it is not known where diseased plants are located. Presently, the most ideal method for finding a diseased plant is a disease census, taking plant tissue samples from every plant and testing for the presence of *X. fastidiosa*. However, this method is not economically feasible; such a census applied to a 40-acre vineyard (ca. 18,000 vines) would exceed \$100,000 in sampling and testing costs. An alternative method to find diseased plants is to take leaf samples from plants expressing disease symptoms and confirming the presence of *X. fastidiosa* with an enzyme-linked immunosorbent assay (ELISA). This symptom-based disease survey can provide a relatively low survey cost when disease incidence is very low. However, it becomes prohibitively expensive to sample and test every symptomatic plant when the percentage of vines with disease symptoms exceeds 1% in case of Pierce's disease (Perring et al. 2005). It is especially difficult to use a symptom-based survey when other stress factors (e.g. drought and salt damage) that express disease-like symptoms exist (Krell et al. 2006). Thus more economical methods that can monitor large areas are needed for detection of *X. fastidiosa*-induced plant diseases such as Pierce's disease of grapevines and bacterial leaf scorch of shade trees. This study was conducted to develop a sampling plan to locate *X. fastidiosa*-infected plants on a landscape scale by utilizing aerial imagery. A landscape-level sampling plan enables extension and government researchers to make recommendations for *X. fastidiosa* management on a landscape scale by prioritizing areas and plants to sample (i.e. hot-spot sampling).

## MATERIALS & METHODS

The objective of a landscape-level detection of *X. fastidiosa*-infected plants is to assess disease distribution over large geographic areas. Clearly, it is impractical to visit every plants and search for disease infection, so a method is needed for prioritizing areas to sample. In our previous studies (Park et al. 2006), we reported on a potential "signature" of areas with Pierce's disease of grapevine (Fig. 1). We found that 82% of the diseased grapevines were adjacent to two to six consecutive missing, dead, or replanted grapevines in a row. We hypothesized that these signature areas might be caused by vines that had died from Pierce's disease or from growers rouging diseased vines. If these signatures can be seen in aerial photographs, then sampling vines around the signature areas may lead to finding additional diseased vines. To test the hypothesis, we conducted field sampling in Kern County, California. We obtained high-resolution (0.6 to 1-m resolution) aerial imagery taken in 1998–2005 from the National Agriculture Imagery Program of the United States Department of Agriculture, the National Aerial Photography Project of the United States Geological Survey, and the Digital Map Library at the University of California, Santa Barbara. The imagery was incorporated into an established geographic information system (GIS) generated for the glassy-winged sharpshooters and Pierce's disease (Park et al. 2006).

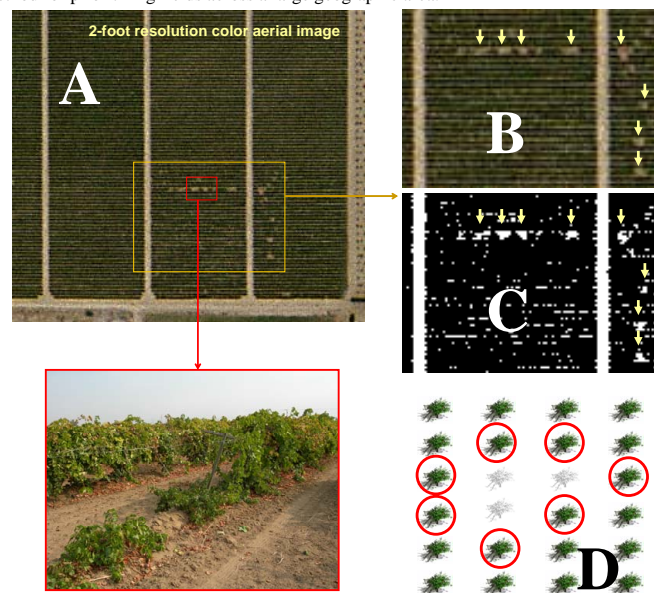


**Fig. 1.** Progress of disease caused by *X. fastidiosa* in a vineyard in 2002-2003. Note that new infections were found near dead or removed vines. These dead or removed vines generated a 'disease signature' when they were shown from aerial imagery (Fig. 2). Some of new infections didn't show any symptoms but were *X. fastidiosa* positive. This example vineyard was observed in Bakersfield, California.

➔ Indicating disease signature areas may be detected from high-resolution aerial images

## RESULTS & DISCUSSION

We found that disease signature areas were visible in aerial imagery (Fig. 2A). The signature areas (arrows in Fig. 2B) were clearly confirmed through post-imagery processing using a GIS (arrows in Fig. 2C). We conducted an additional study to test the validity of the signature areas in the Coachella Valley, California; the study area included 1,800 ha of vineyards. Three aerial photographs (infra red, natural color, and black/white) with 0.7–1-m resolution were used to identify signature areas. We identified 57 signature areas in 25 vineyards throughout the study area. Each signature area was located with GIS and global positioning system (GPS). By sampling grapevines around these signature areas (Fig. 2D), we confirmed the presence of vines infected with *X. fastidiosa* in 14% of the signature areas. This yielded more *X. fastidiosa*-infected vines than we found with symptom-based surveys conducted over the previous four years (2001–2004) in the same area (Perring et al. 2005). In conclusion, this study indicated that sampling plants around disease signature areas caused by *X. fastidiosa* could provide a higher chance of finding diseased vines than a symptom-based survey of Pierce's disease and bacterial leaf scorch. In addition, sampling with disease signature could be an economically feasible method for prioritizing fields across a large geographic area.



**Fig. 2.** Disease signature areas caused by *X. fastidiosa* detected by high-resolution aerial imagery. **A**, aerial view of an example vineyard; **B**, disease signature caused by removing of disease plants or dead plants; **C**, disease signature areas automatically detected with white areas after image processing; **D**, sampling plants (red circles) to test for the presence of *X. fastidiosa* – plants adjacent to signature areas.

## REFERENCES CITED

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