Title of report: Renewal Progress Report for CDFA Agreement Number 15-0217-SA

Title of project: Assessing Pierce's disease spread in grape lines with novel defensive traits

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Reporting Period: The results reported here are from work conducted between February 2016 and July 2016.

Introduction

This proposal expands on previous work funded by this program to develop PD-resistant grape lines. Previous projects have successfully developed grapevine lines with promising traits conferring resistance against *X. fastidiosa*, including plants expressing the *rpfF* gene, the PdR1 major locus, and the HxfB protein (Meredith et al 2000; Walker and Tenscher 2014; Lindow et al 2014). All these grape lines exhibit low symptom severity when inoculated with *X. fastidiosa*. We propose to expand upon previous work by testing the potential of PD-defended grapevine lines to reduce the spread of *X. fastidiosa* using a multi-disciplinary combination of transmission experiments and mathematical modeling. Using this approach and HxfB-producing plants as a case study, we found that while HxfB plants are unlikely to eliminate PD in the field, spread would nonetheless be significantly reduced. Further study will allow us to assess the impacts of these reductions on large-scale and long-term PD spread in resistant grape lines.

Objectives

The overall goal of this project is to assess the potential for novel defensive traits in grapevine lines to reduce the transmission of *X. fastidiosa* by insect vectors and the prevalence of Pierce's disease (PD) within and among heterogeneous vineyards. We will assess PD epidemiology in two defended lines: transgenic grapevine lines expressing the *rpfF* gene (Lindow et al 2014) and conventionally bred grapevine lines with the *PdR1* dominant locus (Walker and Tenscher 2014). The research consists of three specific objectives:

1. Estimate transmission of Xylella fastidiosa and vector feeding behavior on novel PD-defended grapevine lines.
2. Assess large-scale and long-term PD prevalence in defended grapevine vineyards.

3. Inform vineyard managers on the efficacy of novel PD defenses.

Objective 1. Estimate transmission of Xylella fastidiosa *and vector feeding behavior on novel PD-defended grapevine lines.*

Last summer we estimated transmission rates from *rpfF*-expressing grapevine plants by the sharpshooter vector *Graphocephala atropunctata.* As reported in our February 2016 Interim Progress Report, we found a modest reduction in transmission from infected *rpfF* plants but the rate did not differ significantly from near-isogenic wild-type plants. We also found no relationship between distance from inoculation point and probability of transmission, for either plant genotype.

Following up on this experiment, this summer we are conducting a similar transmission test with the sharpshooter vector *Homalodisca vitripennis*. But we will not only be testing acquisition by vectors from infected *rpfF* and wild-type plants; we will also be testing for differences in inoculation rates of *H. vitripennis* into the two grape genotypes. We will also be investigating in more depth how *rpfF* expression *in planta* influences the movement of *X. fastidiosa* in stem and petiole tissue. Based on our previous results, we predict that there will be a clear relationship between distance from point of inoculation and vector acquisition rate from stem tissue, but there will be no relationship with distance and acquisition from petioles. This will provide us with mechanistic insights into how *rpfF* expression influences vector transmission of *X. fastidiosa*.

This summer we are also investigating the influence of the PdR1 major locus on vector feeding behavior and transmission. Sharpshooter vectors, when given a choice, avoid feeding on Pierce's Disease symptomatic plants. We are using measures of preference and transmission rates of *G. atropunctata* to understand the progression of both infectiousness and disease symptoms between PdR1 resistant plants and near-isogenic susceptible plants. This experiment will provide critical insights into the precise nature of defense conferred by the PdR1 locus—whether it is a resistance or tolerance trait—and the risks of enhanced spread of *X. fastidiosa* from PdR1 plants. Both experiments, with *rpfF* and PdR1 plants, are on-going.

Objective 2. Assess large-scale and long-term PD prevalence in defended grape vineyards

As described in our previous report, our work to develop spatially-explicit epidemic models are on-going. Based on previous results, we are focusing our modeling efforts on the interactive effects of spatial distribution of *X. fastidiosa* and vector feeding preference based on plant infection status. We are leveraging the modeling approaches of Webb et al. (2007) and Chiyaka et al. (2012) to model within- and among-plant pathogen distribution, and the approach of Zeilinger and Daugherty (2014) to model vector feeding preference. Model development is still in progress.

Objective 3. Inform vineyard managers on the efficacy of novel PD defenses

We will begin work on objective 3 when we have more results from Objectives 1 and 2.

Publications and Presentations

As we are in the early stages of the project, no publications or presentations have been made for our results.

Project Relevance

While plants expressing *rpfF* and *PdR1* genes show great promise for alleviating Pierce's disease in infected plants, it remains unclear whether these traits reduce the spread of *X. fastidiosa* within and among vineyards. By investigating the epidemiological effects of these novel defensive traits, we will provide critical information on the efficacy to reduce the spread of *X. fastidiosa* and the potential role that defended plants could play in integrated disease management. Our work will also provide a general framework through which the efficacy of other novel plant defenses can be assessed.

In addition to the direct significance of our proposed work to PD management, the work will inform fundamental and long-standing questions in the field: (1) What are the epidemiological consequences of different forms of host defense against pathogens? (2) What are the most important components of the *X. fastidiosa* transmission process for determining the PD prevalence, and does this depend on the dominant vector species? (3) How can plant defense and vector management complement each other to reduce pathogen spread?

Lay Summary

The Pierce's disease (PD) research community has developed grapevines that exhibit novel and promising defenses against *Xylella fastidiosa* and have the potential to reduce crop damage from PD. Yet it remains unknown if these novel defensive traits will increase or decrease large-scale spread of PD within and among vineyards, which is a critical dimension of sustainable disease management. We are conducting transmission experiments with important insect vectors of *X. fastidiosa* and using data from these experiments to explore pathogen spread using mathematical models. We will assess the efficacy of defenses by comparing simulated spread in defended and susceptible vineyards and use these data to inform vineyard managers of how to minimize disease outbreaks across California. So far, our results suggest that the blue-green sharpshooter (*Graphocephala atropunctata*)—an important insect vector—is capable of acquiring and transmitting *X. fastidiosa* from transgenic resistant grapevines and conventional susceptible grapevines at similar rates.

Status of Funds

Funds are being used as originally proposed.

Status of Intellectual Property

No intellectual property has been developed as part of this project.

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