Sumary Final Report for CDFA Agreement Number 17-0332-000-SA

Title of project:
The epidemiology of novel *PdR1* resistant grapevines: epidemic and vector movement models to support integrated disease management

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Brief background information
Resistant cultivars of agricultural crops are integral to sustainable integrated disease management strategies. Our previous work indicated that grapevines that express the *PdR1* gene exhibit resistance against *Xylella fastidiosa*, and are likely to slow the spread of *X. fastidiosa* among vineyards. In the current project, we have tested the generality of our previous observations, by testing *PdR1* resistant and susceptible genotypes into our vector transmission experiments and integrating greater biological detail into our epidemic modeling work. Our results suggest that the *PdR1* gene may lengthen the incubation period, increasing *X. fastidiosa* transmission, but induced resistance conferred by the gene may ultimately reduce spread over the long-term. Vector feeding preference, host resistance, and transmission are clearly dynamic, changing over the course of disease progression. It also remains unclear how growers may incorporate these hybrid plants into their production; we found that the longer the planned age of a vineyard, the greater the area that growers should plant with *PdR1* vines.

List of objectives
Specifically, we ask, under what ecological conditions and spatial arrangements will the use of *PdR1* vines reduce *X. fastidiosa* spread and maximize economic benefits to growers? The research consists of three objectives:

1. *Test the effects of* PdR1 *resistant plants on vector feeding preference and transmission of* X. fastidiosa
2. *Model the optimal mixture of* PdR1 *and susceptible grapevines to reduce* X. fastidiosa *spread and maximize economic return*
3. *Estimate dispersal of insect vectors from field population data*

. we tested how vector feeding preference mediates transmission from hybrid grapevine cultivars providing defense against the pathogenic bacterium *Xylella fastidiosa,* conferred by the *PdR1* gene. We measure a range of epidemiologically relevant parameters in a series of vector transmission experiments.

. we show that vector feeding preference changes over the course of disease progression, and that vector feeding preference is clearly important but does not predict transmission alone.

. the duration of the incubation period, in which plant hosts are infectious but asymptomatic, is likely when most vector transmission occurs.

. results suggest that the *PdR1* gene may lengthen the incubation period, increasing *X. fastidiosa* transmission, but induced resistance conferred by the gene may ultimately reduce spread over the long-term. Vector feeding preference, host resistance, and transmission are clearly dynamic, changing over the course of disease progression, in *X. fastidiosa* pathosystems and likely other systems.

. we isolated 105 distinct secondary metabolites from our source plants: 20 phenolics from leaf blades, 21 phenolics from stems, and 64 volatiles from leaf blades, 28 of which were unidentified. We found that phenolics and volatiles clearly differed between Resistant and Susceptible source plants and this difference increased over time.

. our model predicts that growers who adopt a more short-term strategy—meaning that they are primarily focused on maximizing returns in a shorter time frame—should not plant *PdR1* vines but should only plant susceptible vines. However, growers who adopt a more long-term strategy should plant a mixture of *PdR1* and susceptible vines. Generally, the longer the harvest time, the greater the area that growers should plant to *PdR1* vines. These results should clearly depend on the epidemiological conditions experienced by growers.

. our bioeconomic model results assumed no winter recovery. We hypothesize that incorporating winter recovery into the model will lead to a broader set of epidemiological and economic conditions under which planting a mixture of *PdR1* and susceptible grapevines would maximize grower return; for example, winter recovery may lead to planting *PdR1* being beneficial under short-term planting strategies.

. results indicate that *PdR1* hybrid grapevines can produce transmission rates greater than those from susceptible vines, potentially posing a risk of enhancing spread of *X. fastidiosa*. However, our results also suggest that these higher transmission rates may be transient, followed by transmission rates similar or lower than those from susceptible plants. This may be due to some form of induced resistance in the plants, though our attempts to quantify the form of resistance were inconclusive.