Vibrational Spectroscopy-Based Chemometrics to Map Host Resistance to Sudden Oak Death[1]

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Abstract

A strong focus on tree germplasm that can resist threats such as non-native insects and pathogens, or a changing climate, is fundamental for successful conservation efforts. This project is predicated on the fact that genetic resistance is the cornerstone for protecting plants against pathogens and insects in environments conducive to the attacking organisms, a principle we have extensively applied to the study of coast live oak (CLO – *Quercus agrifolia*) interactions with *Phytophthora ramorum* in California wildlands. The largest obstacle to the implementation of host resistance as a tree health management tactic in forest environments, as well as for germplasm conservation, is the lack of tools for the rapid phenotyping of tree disease resistance in the field. Previously, in work conducted in Briones Regional Park, East Bay Regional Park District (EBRPD), Alameda County, California, we have demonstrated that the levels of soluble phenolics extracted from CLO trunk phloem can predict resistance to *P. ramorum* by way of a logistic regression model that included total phenolics and four individual phenolic compounds: ellagic acid, a partially characterized ellagic acid derivative, and two chromatographic peaks representing two uncharacterized phenolic compounds (McPherson and others 2014a). *In vitro* tests subsequently showed that ellagic acid was fungistatic against *P. ramorum* and total phenolics were fungicidal at physiologically relevant concentrations.

In further developments, here we show that Fourier-transform infrared (FT-IR) spectroscopy, a chemical fingerprinting technique, can also be used to identify CLO resistant to *P. ramorum* prior to infection (Conrad and others 2014). Soft independent modeling of class analogy identified spectral regions that differed between the resistant and susceptible trees in Briones Regional Park. Based on chemometrics, resistant CLOs constituted 20% of the population, which was about the same as the average estimate based on disease expression. Regions most useful for discrimination were associated with carbonyl group vibrations, which are often associated with phenolics. Additionally, the levels of two putative phenolic biomarkers of resistance, including ellagic acid and an unidentified phenolic, were predicted using partial least squares regression; > 99% of the variation was explained by this analysis. We expect that our tool will be a real game changer in sudden oak death (SOD) management, because currently there is no other technology to determine tree resistance in advance of a disease front (Conrad and others 2016). This predictive power is unprecedented for field trees, and recent work in other pathosystems, specifically whitebark pine-white pine blister rust, and Port-Orford-Cedar – *Phytophthora lateralis*, has shown that FT-IR spectroscopy can be used to predict resistance in the progeny of well-characterized families, in addition to that of the parent trees.

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We are now planning to apply these novel techniques to map resistant CLO in Redwood Regional Park, (EBRPD) (McPherson and others 2014b). The park is rather well characterized in terms of SOD incidence and distribution, based on longitudinal studies anchored on permanent plots. We expect to demonstrate that FT-IR spectroscopy can be a useful approach for managing forests impacted by SOD, for example for protecting resistant populations from fire, logging, and development, as well as in other situations where emerging or existing forest pests and diseases are of concern.

Literature Cited

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