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# Developing an Online Grapevine Trunk Disease Diagnostic Aid

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## Abstract

We face critical challenges in educating growers on wood-canker diseases of grapevines. Unlike other major diseases that appear every year with obvious symptoms (e.g., powdery mildew of grape), wood-canker diseases are often go unnoticed, yet they have more certain and detrimental effects on the plants. Because of this lack of sensational symptom development within a short period, it is difficult for agricultural educators to convince the growers to take urgent action. Modes of delivering extension-related information are changing. Reduced extension education budgets and changes in growers' expectations have led to fewer of the standard, face-to-face meetings between extension agents and growers, and instead, have shifted toward distance-learning style approaches. In order to address these issues, we have developed a new web-based pictorial diagnostic key tool for grapevine trunk diseases. This tool aids users to determine a target grapevine trunk disease using a series of pictorial keys from different tissues of grapevines (leaves, trunks, cluster, etc.). Once enough information is obtained, it will provide the user a list of recommendations for management. This tool covers not only trunk diseases, but also some bacterial diseases and abiotic disorders that are similar in symptom expressions. It is hosted at [treeandvinetrunkdiseases.org](http://treeandvinetrunkdiseases.org), and the website is freely available.

**Keywords:** grapevine, trunk disease, abiotic disorder, diagnostic, application, web

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## 1. Introduction

Various trunk diseases of grapevines affect the grape production around the world [1]. The causal agents of grapevine trunk diseases constitute a complex of fungi mainly belonging to the filamentous Pezizomycotina, which belongs to Ascomycota. Common diseases are

Botryosphaeria canker, Eutypa dieback, Phomopsis dieback, and Esca (also known as Petri disease). Damages caused by these diseases vary in the expression of symptoms. Damages can be made on fruiting structures (spurs, rachis, etc.), trunks and cordons, and/or the vascular system. Infection may result in delaying of fruit ripening and/or overall decline of vines [2]. Since these diseases can affect the trunk of grapevines, which is a semipermanent structure for grape production, the impact of trunk diseases is long-term, and often time, the only remedy is the replacement of infected vines [3].

Unfortunately, field identification of these trunk diseases is challenging because symptoms are very similar to each other. For example, *Botryosphaeria* spp., *Phomopsis viticola*, and *Eutypa lata* can cause dead spurs and cordons. In fact, there was a confusion on the causal agent of grapevine “dead arm” disease where people discussed whether this disease was caused by *Eutypa* or *Phomopsis* [4]. There are some characteristic symptoms such as discoloration of leaves (called tiger striping) of Esca, but it can vary year-to-year [5], or as in symptoms of *Eutypa*, symptom expression may depend on the environmental factors [6].

Moreover, there are a number of other causes, from biotic factors such as bacterial infection by Pierce’s disease pathogen, *Xylella fastidiosa*, to abiotic factors such as winter cold injury that can cause similar symptoms because these factors damage the vascular system of grapevines. Depending on the cause of the problem, management practice will differ; however, extension publications, such as Fact sheets, tend to describe only one or a few diseases. To learn all the possible causes, growers need to read several sources of information. This situation makes more difficult for growers as well as extension and agricultural educators to communicate about diseases and disorders associated with the grapevine trunk.

In order to address this complex issue, with a collaboration of the project PI, Dr. Kendra Baumgartner at USDA/ARS at Davis, CA, USA, we launched a new website (treeandvine-trunkdisease.org) (‘trunk disease website’ hereafter). This website is designed not only to distribute information on current research topics by a group of researchers but also to provide trunk disease management information that growers can use.

One of the tools that the website offers is a grapevine trunk disease diagnostic application (‘trunk disease app’ here after). This web-based application is designed to guide users to diagnose grapevine trunk diseases and disorders by providing pictorial keys. Although the name states trunk disease, this application covers not only fungal trunk diseases but also bacterial diseases that can affect the vascular system and abiotic disorders that may cause similar symptoms.

## 2. Platform for the application

Initially, our idea was to develop a smart device application, such as an app for iOS or Android OS. However, we decided to use a website because of the ease of development and maintenance. A smart device application run better under an appropriate operating system, but it requires us to develop two applications. Also, in order for users to obtain the smart device application, they need to visit the proper application store to download. Depending on the size of the application or the version of the operating system, some users may not be

able to install the app. Moreover, if there is a major update on either of the operating system, the application may require an update. In the worst-case scenario, these operation system updates can make the application entirely useless.

On the other hand, with an application on the website, we can focus our resources on one location. If we keep the coding simple, users do not need to install any application on their devices. Since it is basically a website, any devices with a web browser can access the information. This lack of dependency on the platform helps to reach out more audiences since some growers may not be as technologically perceptive as the others may.

Therefore, we developed our application on a remote web server that hosts our website. The content management system was WordPress (Wordpress.org), and coding was a combination of the HTML and the CSS. Using a template of WordPress that was designed to automatically scale and place menu items based on the platform that was accessing the website, we developed a mobile- (or smartphone-) ready website with ease.

### 3. Diseases and disorders covered by the application

As noted earlier, although this application has a name associated with grapevine trunk diseases, it handles more than trunk diseases. **Table 1** shows the list of diseases and disorders that are covered by the application.

Type	Common name	Causal agent
Fungal disease	Botryosphaeria canker	<i>Botryosphaeria</i> spp.: <i>B. australis</i> , <i>B. dothidea</i> , <i>B. lutea</i> , <i>B. obtusa</i> , <i>B. parva</i> , <i>B. rhodina</i> , and <i>B. stevensii</i> [7]
	Esca, Petri disease	<i>Phaeoconiella chlamydospora</i> <i>Phaeoacremonium minimum</i> Other <i>Phaeoacremonium</i> species [8]
	Eutypa dieback	<i>Eutypa lata</i> [4]
	Phomopsis dieback	<i>Phomopsis viticola</i>
	Crown gall	<i>Rhizobium vitis</i> (also known as <i>Agrobacterium vitis</i> ) [9]
Bacterial disease	Pierce's disease	<i>Xylella fastidiosa</i> [10]
	North American Grapevine Yellows (NAGY)	Phytoplasma (related to <i>Candidatus Phytoplasma pruni</i> [11])
Abiotic disorder	Frost damage	
	Nutrient deficiencies	
	Other physical injuries such as cold and hail damage	

**Table 1.** Diseases and abiotic disorders that are covered in the trunk disease app.

## 4. Interface and plug-ins

WordPress theme Parabota ([www.cryoutcreations.eu](http://www.cryoutcreations.eu)) was chosen as an interface of the website since it is a scalable template that automatically recognizes the operation system of the site visitor, then scales images and rearranges menus. In addition, a plug-in WPPatch ([www.wptouch.com](http://www.wptouch.com)) was installed to enhance the experience of mobile phone users. We used a package RPS image gallery ([redpixel.com](http://redpixel.com)) to add a description (footnote) to each image, place images as columns, and also allow the site visitor to click image to enlarge. The usage of the website is tracked by Google Analytics ([www.analytics.google.com](http://www.analytics.google.com)).

## 5. Trunk disease app interface

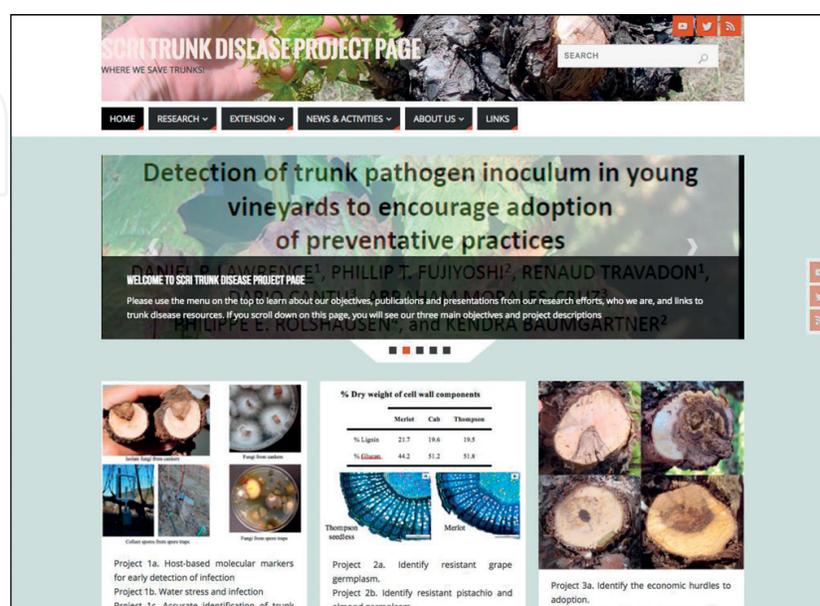
When a site visitor comes to the trunk disease website (**Figure 1**), which is a portal site for many project pages, including the trunk disease diagnostic app, the user finds the app under the main menu 'Extension.'

The menu opens an introductory page that explains how this application works. Then, the application starts by showing four tissues of grapevine, 'leaves', 'shoots', 'clusters', and 'cross sections and bark' (**Figure 2**).

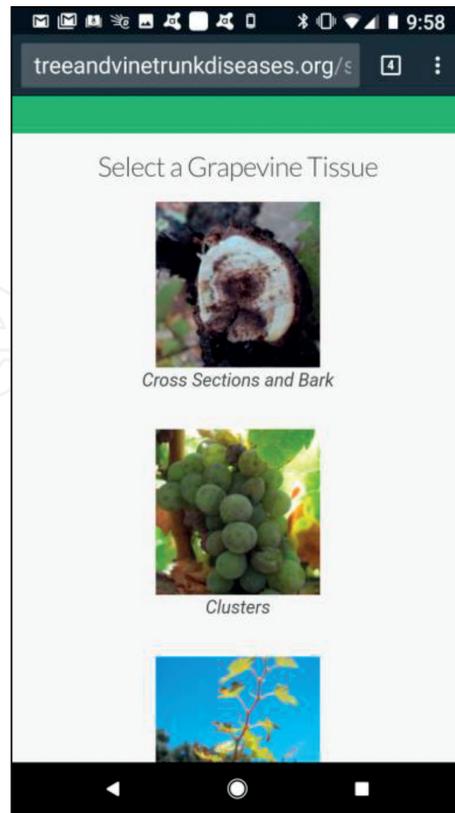
Once the user clicks the tissues that are showing symptoms, the application displays different types of symptom for the user to select (**Figure 3**).

Then, the application follows up with a series of questions. For example, even if the user chooses leaves as symptomatic tissue, the application shows pictures of other parts of the grapevines (**Figure 4**).

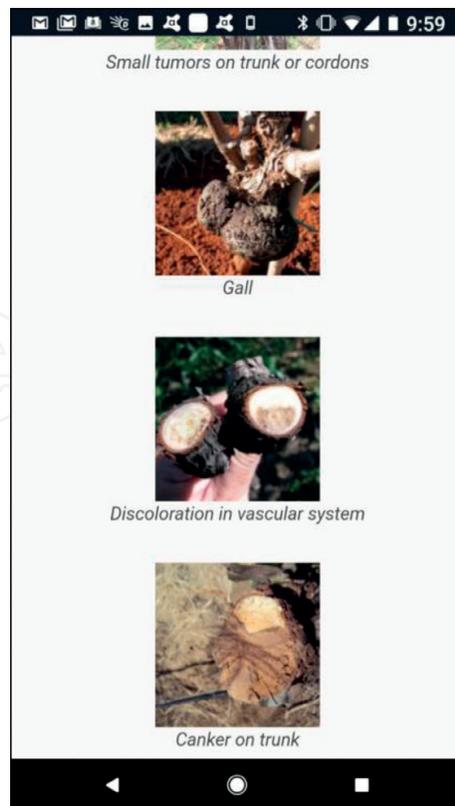
After answering several questions, the application displays the most likely scenario for the symptoms (**Figure 5**).



**Figure 1.** The SCRI trunk disease project page on a computer screen ([treeandvinetrunkdiseases.org](http://treeandvinetrunkdiseases.org)).



**Figure 2.** Trunk disease app's opening dialogue on a smartphone screen: Asking users to select a symptomatic tissue.



**Figure 3.** Trunk disease app on a smartphone screen: app users click or tap the best-described symptom picture to determine the disease in question.

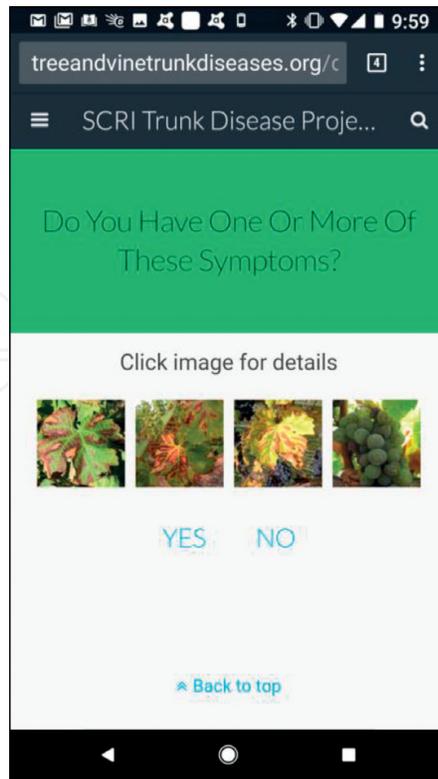


Figure 4. Trunk disease app on a smartphone screen: The app shows multiple pictures to app users for the confirmation.

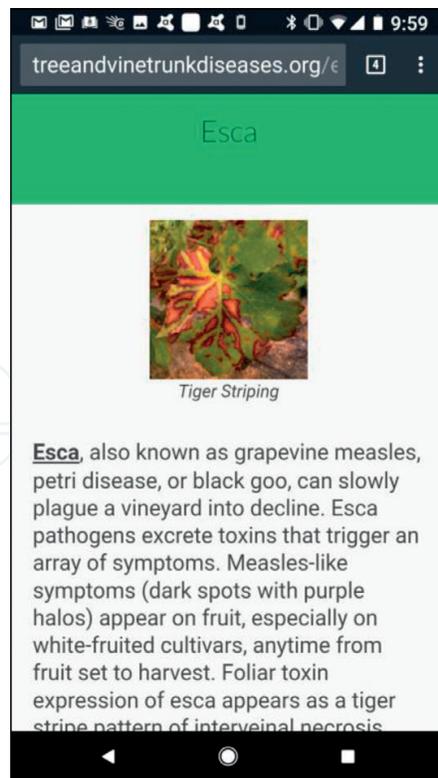


Figure 5. Trunk disease app on a smartphone screen: A diagnostic screen to display the most likely disease based on the user inputs.

## 6. Summary and conclusions

The major issue with grapevine wood-canker diseases and other trunk-related disorders is the difficulty of diagnostics. Many growers overlook the symptoms simply because they are not familiar with these diseases and disorders. In addition, these diseases do not cause immediate damage to the infected vines. However, when we look into the life of a vineyard, the long-term effect of these diseases can be detrimental [12]. One of the issues is the lack of obvious symptom expressions from trunk diseases and disorders. Many of the symptoms are similar to each other, and since many extension education materials often talk about one disease, it is difficult for the growers to cross-examine symptoms to find the diseases that they are dealing with.

In order to address these issues, we have developed a new web-based pictorial diagnostic key tool for grapevine trunk diseases and other disease and disorders that affect the trunk of grapevines. This application is freely available through our project page ([treeandvine-trunkdiseases.org](http://treeandvine-trunkdiseases.org)). This diagnostic tool aids users to determine a target grapevine trunk disease and disorder with a series of pictorial keys from different tissues of grapevines (leaves, trunks, cluster, etc.). Users will answer several questions by matching symptoms with pictures. Once enough information is obtained, it will provide recommendations for management. In order to appeal to many users, we selected mobile-friendly themes and plug-ins in the website and application.

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