

EXTENDED ABSTRACT

From science to farmers: VITIROOT shiny app for grapevine rootstock recommendation

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INTRODUCTION

Rootstocks serve as an essential and critical component in viticulture. They influence root development and density, water uptake capacity, drought resistance, and the vine's adaptability to a range of soil conditions, including nutrient availability, pH, and salinity. Beyond their well-known role in pest and disease resistance, they also exert a strong influence on scion performance, particularly with respect to vigor, phenological development, and yield (Pisciotta 2013; Naulleau et al. 2021; Chen et al. 2024). They also recognized to impact fruit yield and chemical composition and priorities hence wine quality (Clingeffer et al. 2019; Klimek et al. 2022).

Despite a long history of rootstock use and ongoing research, selecting the optimal rootstock for a specific site remains challenging. An optimal rootstock choice relies on multiple interrelated factors, including agronomic needs, productivity desires, soil type, scion-rootstock compatibility, vine resilience, and adaptability to specific environmental conditions and enological goals (Clingeffer et al. 2019; Carrere et al. 2022). In the face of climate change, rootstock selection is also emerging as a key strategy for adaptation,

particularly in response to increasing drought, salinity, and extreme heat events (Santesteban et al. 2023). Hence, given these evolving challenges, the selection of an appropriate rootstock necessitates a comprehensive understanding of site-specific conditions and long-term adaptation needs. Despite the critical importance of rootstock choice, in practice, selection is often based on general agronomic consultancy, nursery recommendations, or anecdotal experience. While these sources can provide helpful guidance, they may be suboptimal or misaligned with long-term objectives. This is particularly relevant given that accessing experts, site-specific advice or conducting field trials is often costly and logistically challenging for most small- to medium-scale growers.

To address these challenges and support more accurate, accessible, and data-driven decision-making, we developed VITIROOT, an interactive, open-source, and user-friendly web application that helps grape growers select the most appropriate rootstock based on their specific vineyard conditions.

RESEARCH OBJECTIVES

VITIROOT is an interactive, open-source, and user-friendly web application designed to assist grape growers in selecting suitable rootstocks based on vineyard-specific conditions. The application provides tailored recommendations by integrating key variables such as desired vine vigor, water availability, soil pH, salinity, drought tolerance,

drainage capacity, and resistance to pests like nematodes and phylloxera. It also offers guidance on scion-rootstock compatibility. By delivering personalized, science-based decision support, VITIROOT aims to optimize rootstock selection and help growers make informed choices based on the unique characteristics of their site.

MATERIAL AND METHODS

Rootstock database extraction and compilation

A total of 21 rootstocks (*Kober 5BB*, *SO4*, *420A*, *161-49 C*, *1103 P*, *110R*, *140RU*, *775 P*, *779 P*, *Rupestris du Lot*, *101-14*, *3309 C*, *196-17*, *Gravesac*, *41B*, *Fercal*, *M1*, *M2*, *M3*, and *M4*) were initially selected based on their agronomic relevance and usage in Sicilian and Southern European vineyards. As a first step, we compiled and extracted all available materials and information from scientific articles, reports, theses, and online databases (VCR, Vinifera etc...) When available, the following parameters were collected: vigor, compatibility and affinity with commonly cultivated grapevine varieties,

tolerance to active limestone (expressed as % CaCO₃), IPC, adaptability to various soil conditions (e.g., wet, dry, sandy, clay, acidic, and saline), and drought tolerance capacity. Resistance to phylloxera and nematodes was also considered. Since data were sourced from multiple databases with varying scales and scoring systems, all traits were first standardized in terms of terminology and then rescaled to a uniform range. When different values were reported for the same trait across sources, the arithmetic mean was calculated, and traits were weighted based on the frequency of occurrence.



Implementation

To develop the app, we implemented a hierarchical Boolean filtering system to guide rootstock recommendations. Filtering conditions were prioritized based on their impact, starting with the most uncontrollable or limiting environmental factors, such as water availability, and followed by more adjustable or lower-weighted criteria. Logical conditions were encoded as Boolean variables, allowing for flexible combinations of filters based on user input. The VITIROOT application was developed in the R programming language using the Shiny

App description

The VITIROOT application interface is organized into three main panels: “About”, “Rootstock Recommendation”, and “Additional References”. The “About” panel provides background information on scientific rationale, methodology, and references supporting the tool. The “Rootstock Recommendation” panel contains a user-friendly input form where users can specify vineyard conditions such as irrigation, vine vigor, soil pH, salinity, drainage, and pest

Results Questions

As a first step, the user is prompted to answer a series of questions regarding vineyard conditions and rootstock preferences: water availability (no irrigation, limited, or ample irrigation); desired vine vigor (not important,

Output

Once these parameters are selected by the user, the app filters and displays a list of the recommended rootstocks. For each rootstock, an interactive radar chart (generated using Plotly.js) visualizes its key agronomic traits, allowing users to quickly grasp how each option aligns with the desired criteria. Moreover, VITIROOT also features a dynamic affinity heatmap display, showing the level of compatibility between the selected rootstock and a range of commonly cultivated

CONCLUSION

VITIROOT represents a first step towards more informed and data-driven rootstock selection in viticulture. By integrating environmental parameters, viticultural traits, and varietal compatibility into a single decision-support platform, the tool provides practical assistance to growers and researchers. As the application is still under development, our vision is

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framework to provide a user-friendly interface that requires no programming skills or special access permissions. The app utilizes the following R packages: *dplyr*, *shiny*, *plotly*, and *tidyverse*. VITIROOT is freely available on GitHub at the following URL: <https://github.com/Markleb1996/VITIROOT>. To use the app, RStudio must be installed. Detailed instructions for installation and execution are provided in the GitHub repository.

tolerance. Based on these selections, the app dynamically filters a curated dataset and displays a list of recommended rootstocks. In addition, it generates interactive plots for each suggested rootstock and provides information on scion-rootstock compatibility. The “Additional References” panel provides downloadable documentation for each rootstock, enhancing transparency and practical value.

moderate, low, or very high); soil pH (highly acidic, neutral, or moderately alkaline); soil drainage (unknown, low, or high); and tolerance to phylloxera and nematodes (yes or no).

grapevine varieties. Compatibility is categorized into four levels (Optimal, Good, Medium, and Low), and is organized by red and white cultivars for clearer interpretation (Figure 1). In addition, VITIROOT provides a comparative tool that enables users to evaluate key viticultural traits across multiple rootstocks, facilitating more informed selection when several rootstocks meet the desired criteria.

to expand VITIROOT into a comprehensive, international database that includes all known and commercially available rootstocks worldwide. We welcome collaboration with academic institutions, nurseries, and viticulture professionals worldwide to enrich the dataset and improve the accuracy, relevance, and reach of the tool.

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TABLES AND FIGURES

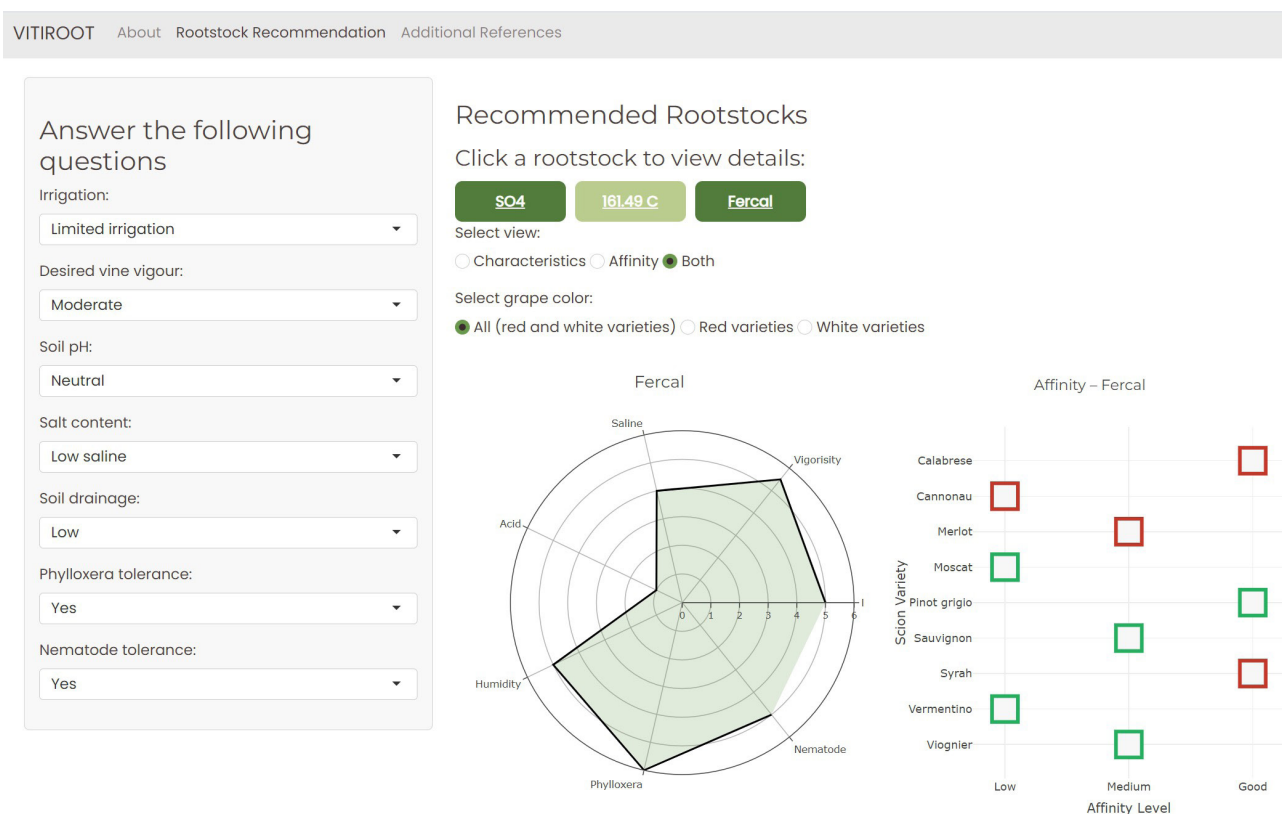


Figure 1. A screenshot of an example output from VITIROOT Shiny web application simulation, displaying descriptive plots of the Fercal rootstock’s characteristics and its compatibility (affinity) with various scion varieties.