Development of an image database of apple tree branches affected by european canker

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Abstract

European canker is a significant disease affecting apple trees in Brazil. Manual detection is labor-intensive and time-consuming, with limitations in the early identification of lesions. This study aims to develop faster and more efficient detection methods through an automated system based on sensors or image processing. To achieve this, the creation of a comprehensive image database of affected apple tree branches is essential. The research was divided into two stages, both focused on building this database. The first stage involved compiling an RGB image dataset of healthy and infected branches. The second stage documented canker at various stages of development through a controlled inoculation experiment, using RGB and multispectral (725 nm) cameras. Preliminary results indicate that the physiological changes caused by infection produce detectable differences in the images, particularly at wavelengths above 700 nm. This underscores the potential of this spectral range for detecting diseased branches. The resulting database will enable detailed spectral analysis and will later be used to train convolutional neural networks (CNNs) to identify early infection patterns.

Keywords: *Neonectria ditissima*; Spectroscopy; Disease monitoring.

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1. Introduction

Apple production in Brazil is predominantly concentrated in the Southern Region and represents a sector of significant economic relevance. However, orchard growers face various phytosanitary challenges. Among these, European canker, caused by the fungus *Neonectria ditissima*, stands out as one of the most important diseases affecting orchards in the region (Alves; Czermainski, 2019).

European canker primarily affects the woody parts of the apple tree, such as the trunk, branches, and twigs. During the early stages of fruit development, infection may also occur in the fruit, leading to pre-harvest rot (Xu; Robinson, 2010). Infection by *N. ditissima* generally occurs through wounds, whether natural (such as leaf fall, petal drop, or bud scale detachment) or resulting from management practices (such as pruning or harvesting). Among these, wounds caused by pruning, harvesting, and leaf fall represent the primary infection pathways (Alves; Nunes, 2017).

Accurate and early identification of cankers is critical for effective control and the elimination of inoculum sources. However, manual detection—especially in early stages or when lesions are small and concealed within the tree canopy—presents significant limitations, as it is a time-consuming and labor-intensive task (Zhang et al., 2019).

In this context, the development of faster and more efficient detection methods is essential for optimizing disease management. A study conducted by Alves et al. (2024) observed differences in reflectance above 700 nm between healthy tissues and those affected by European canker, indicating that spectral reflectance may serve as a useful parameter for assessing plant health in relation to this disease.

To facilitate the development and improvement of automated detection systems for European canker in apple trees, the creation of a comprehensive image database of branches is essential. This database should capture the visual and spectral features associated with the disease at various stages of development and under diverse conditions. It must consider not only the progression of the disease but also the phenological stages of the plant. During the active growing season (spring and summer), symptoms are typically associated with wilting leaves and dry branches, whereas in the dormant season (winter), the main symptom is the presence of cankers, which are characterized by localized deformations at the infection sites. Therefore, algorithm development for automated detection will likely need to account for the time of year in which monitoring occurs. Thus, establishing this image database is a fundamental step toward developing tools that enable more precise and efficient identification and geolocation of diseased plants.

2. Methods

This study was divided into two stages, both focused on constructing an image database. All data collection and image acquisition were carried out in the orchards and laboratories of Embrapa Uva e Vinho, located in Vacaria, Rio Grande do Sul, Brazil.

The first stage involved creating a database containing RGB images of both healthy and infected apple tree branches. A portion of the images was taken with the branches still attached to the trees, while another portion consisted of detached, defoliated, and segmented branches, each cut to a standardized length of 5 cm. Branch selection criteria included annual growth shoots with a maximum diameter of 8 mm. These segments were photographed against a white background at a fixed distance of 30 cm.

The second stage focused on developing an image database to document cankers at various stages of disease progression. To achieve this, an inoculation experiment was conducted to enable time-based image acquisition of symptom development.

For inoculum preparation, apple tree branches showing symptoms of European canker were collected from infected plants one week prior to inoculation and maintained in a humid chamber at 20 °C to stimulate sporulation. On the day of inoculation, the branches were examined under a stereomicroscope, and sporodochia were scraped using a scalpel and transferred to a beaker containing sterile distilled water. The initial concentration of macroconidia in the resulting suspension was determined using a hemocytometer. The inoculum suspension was then adjusted to a final concentration of 2×10^4 conidia/mL by dilution with sterile distilled water.

To estimate the germination potential of the conidia, a 50 µL aliquot of the suspension was transferred to Petri dishes containing water-agar medium. Three dishes were prepared, with each dish considered a replicate. The plates were incubated at 20 °C for 6 hours. Germination rate was assessed under a compound microscope at 100× magnification by counting 200 conidia (both germinated and non-germinated).

For the inoculation procedure, 100 healthy branches from 20 plants (five branches per plant) were selected. Superficial wounds were made using a rasp. On 50 of these branches, a drop of approximately 100 µL of the *Neonectria ditissima* suspension (2×10^4

conidia/mL) was applied directly to the wounds. The remaining 50 branches were wounded in the same manner but received only sterile distilled water, serving as control samples. All plants and branches were individually labeled with plastic tags to enable future comparisons.

The inoculated plants were maintained under natural field conditions with respect to temperature and humidity. Photographic documentation began one day post-inoculation and continued on a weekly basis. Images were captured using: a) an RGB camera (Canon Powershot G16); and b) a multispectral camera (Mapir Survey3 RedEdge), featuring a 725 nm spectral band. Image acquisition was preferably conducted in the afternoon to standardize natural lighting conditions. All image files were saved, organized, and classified by date.

3. Results and Discussion

The first stage of the experiment resulted in the collection of a total of 806 images, comprising 425 images of detached infected branches, 286 images of infected branches still attached to the plant, and 95 images of detached branches without visible disease symptoms. In all images of detached branches, the characteristics of both healthy and diseased tissues were clearly observable, as the branches were defoliated (Figure 1). In contrast, the images captured under field conditions were taken during the summer months, post-harvest, and therefore included foliage on the plants. These images enabled a preliminary analysis of the spectral response of tissues affected by European canker.

It was observed that RGB images (400–700 nm) of infected branches on the plant were generally associated with branches exhibiting dry leaves and, in more advanced cases, with leafless branches. A noticeable contrast between healthy and diseased tissues was observed when captured with the multispectral camera (Figure 2).

In the controlled inoculation experiment, the estimated germination rate of conidia was 82.2%. Branches were monitored over a six-week period using both spectral imaging systems (RGB and RedEdge at 725 nm), resulting in a total of 1,200 images—600 of inoculated branches and 600 of control branches. Within the first few weeks post-inoculation, changes in reflectance were already detectable in the 725 nm band images when compared to RGB images (Figure 3).

These preliminary results indicate that the physiological changes induced by infection produce detectable differences in imagery, particularly at wavelengths above

700 nm. The presence of such spectral variations, especially in the RedEdge band, aligns with previous studies conducted by the Embrapa Uva e Vinho research team (Alves et al., 2024).

Based on this structured image database, it will be possible to conduct more detailed spectral analyses and initiate the training of convolutional neural networks (CNNs) to identify patterns associated with the early stages of infection. In a parallel study currently underway as part of the same project, a prototype device equipped with 3D cameras is being developed for apple fruit counting. This prototype may be adapted to include spectral band cameras capable of detecting European canker, using the database currently under development as the analytical foundation.

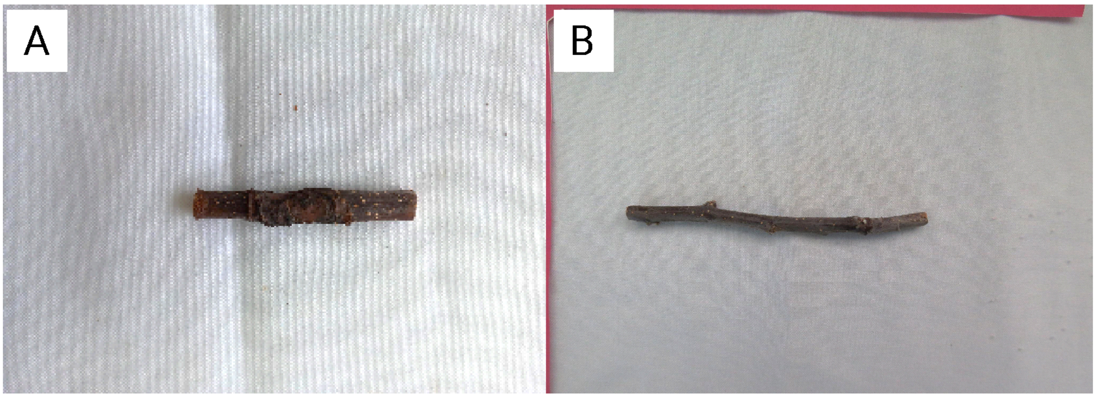

Figure 1. Detached apple tree branches: (A) with symptoms of European canker. **Photo**: Jardel Talamini de Abreu; (B) without symptoms of European canker. **Photo:** Eduardo Carvalho da Silva.

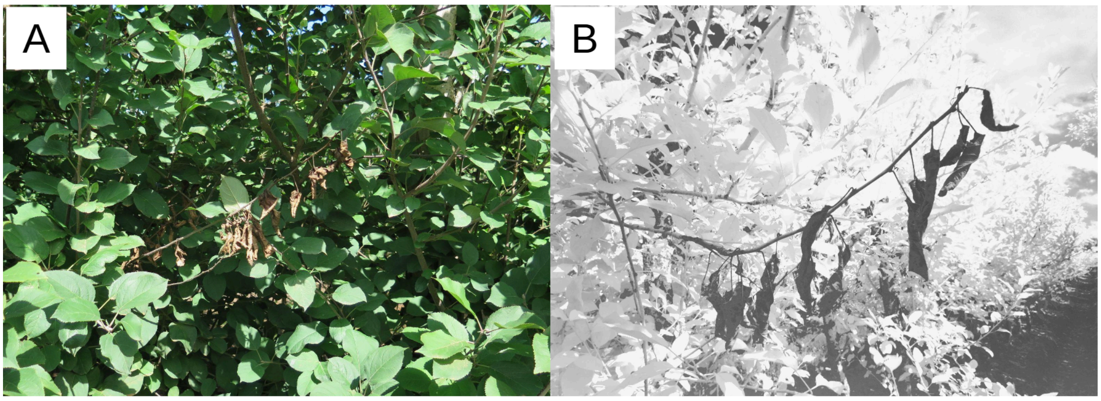

Figure 2. Example of apple tree images under field conditions, affected by European canker: (A) RGB image (Photo by Silvio André Meirelles Alves); (B) image captured with a RedEdge camera.
Photo: Silvio André Meirelles Alves.

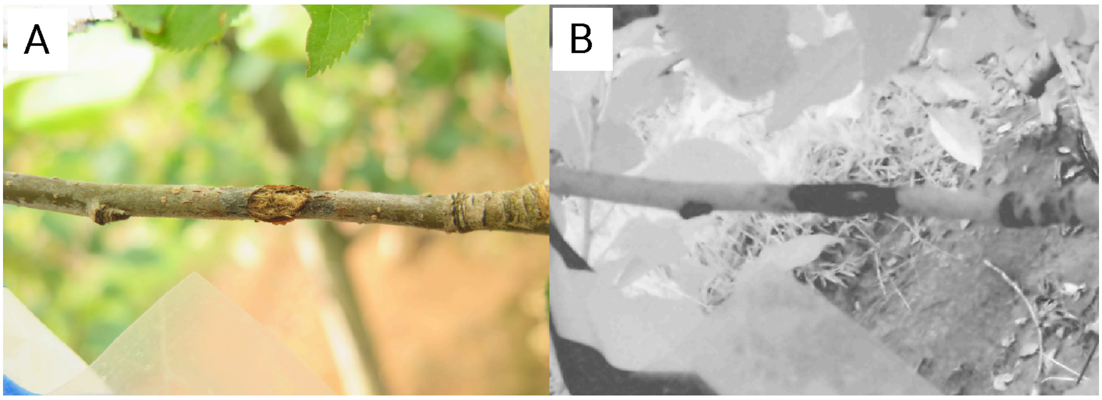

Figure 3. Images of the same branch inoculated with *Neonectria ditissima*: (A) RGB image. **Photo:** Eduardo Carvalho da Silva); (B) image captured with a (B) RedEdge camera. **Photo:** Lucas de Ross Marchioretto.

4. Conclusion

Preliminary results indicate that infection by *Neonectria ditissima* induces detectable spectral changes, particularly at wavelengths above 700 nm, reinforcing the potential of sensor-based approaches for automated disease diagnosis. The construction of the image database represents a crucial step toward developing early detection algorithms. Although the study is still in its initial phase, the data obtained already suggest promising directions for practical applications in plant disease management and precision agriculture. Future studies should focus on expanding the dataset and validating the methods under diverse field conditions.

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