Investigating microstructural changes in leaves by optical coherence tomography at different wavelengths of 836 nm and 1330 nm

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1. Introduction

Recently, optical coherence tomography (OCT) has been widely applied in the field of ophthalmology and dermatology and other fields [1]. However, only, in recent times it has been slowly gaining interest in plant sciences and has been applied to study the virus infection in leaves of orchid [2], study of disease progression in apples [3] and leaf senescence [4] and in exposure of ozone [5]. Leaf microstructure plays a crucial role in its overall development as it is involved in energy production through photosynthesis. Thus, leaf growth is involved in both maintenance and senescence. Imaging techniques such as scanning electron microscopy, X-ray computed tomography, positron emission tomography that require special sample preparation are used extensively for their very high resolution while confocal and multiphoton fluorescence microscopies are limited by the depth to which can be seen. In this study, two OCT systems, namely a spectral domain OCT operating at 836 nm and a swept source OCT operating at 1330 nm have been used to investigate the microstructural organization as a function of the age of the leaf at two different wavelength regions.

2. Methods

The Spectral Domain Optical Coherence Tomography (SD-OCT) system uses a Super Luminescent Diode (SLD) operating at a central wavelength of 836.1nm and a bandwidth of 55.2nm resulting in an axial resolution of 6 µm. X-Z images of 2048 x 512 pixels using a line scan camera with the lateral scanning done using galvano scanners. The OCT system operating at 1330 nm is constructed with a swept source operating at 20 kH and provides X-Z images of 1000x 3840 pixels. A custom made software in labview was used to perform the scanning and collecting images. OCT reflectivity images for a green leaf and a yellow leaf obtained with two different systems are shown for two different wavelengths (Fig.1). The encircled regions indicate the scan regions. As the images were taken separately, the scan regions were not exactly made the same.

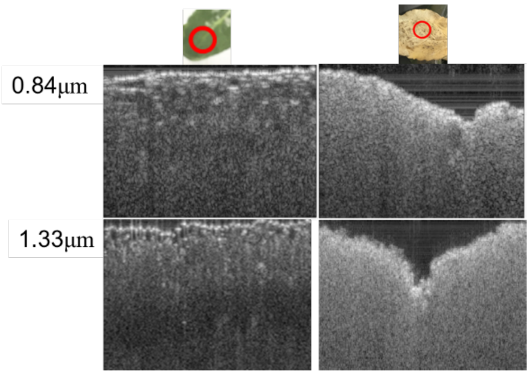

Fig 1. Images obtained with spectral domain OCT at 836 nm (top row) and swept source OCT at 1330 nm (bottom row) for a green (left) and yellowish leaf (right).

3. Results

As can be seen from the figure, the layered and finer structures are visible for green leaf at both wavelengths and such structures are completely destroyed with aging or the senescence of the leaf for both wavelengths. On the other hand, for the green leaf, there is propagation to deeper regions at 1330nm and thus the vein structure could also be visualized that is difficult to see at 836 nm. At the same time, close to the surface, the finer structures seem to appear with higher contrast for 836 nm in comparison to that for 1330 nm. We are currently investigating the differences based on the absorption and scattering at these wavelengths for the leaf by analyzing the depth profiles.

References

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