Diseases detection and hydric stress of sugar cane leaves using photoacoustic spectroscopy and multispectral photography

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Introduction

Agriculture is considered one of the most important economic activities worldwide, for this reason over time it has been evolving and adapting new strategies in order to meet the requirements of producers and different forms of cultivation.

In this work, we have used the photoacoustic spectroscopy (PAS) technique with the purpose to obtain the optical properties of health status of sugar cane leaves.

The spectra of the samples under PAS study (setup described in Figure 2) have been leaves of sugar cane taken from small plants growth in laboratory; some of them became infected, intentionally, with the fungus Curvularia spp (Figure 4).

We have also study sugar cane leaves using multispectral photography in a cane field using an UAV (Unmanned Aircraft Vehicle) that took pictures at several heights in order to complement the PAS study.

The images were merged in order to get an orthomosaic (like the one that is shown in Figure 3). It is a complete picture of the field under study. On the orthomosaic we have used several techniques of image processing searching for visual patterns indicating diseases or even hydric stress.

Also it is known that healthy plants reflects a large part of the near infrared light; on the other hand, unhealthy vegetation reflects in greater proportion the visible light and absorbs the light in the near infrared (Figure 6). A clearly example of this is the Figure 5.

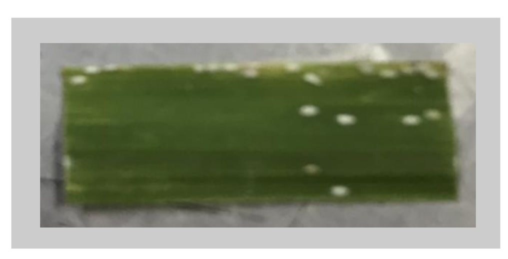

Figure 4. Sugar cane leave sample infected in the laboratory by Curvularia spp.

Experimental

The spectra of the samples were obtained with a handmade photoacoustic spectrometer using the same experimental setup described in Figure 2.

With the propose of complement information we used a multispectral camera; It's a Parrot Sequoia and operates in the bands of Green (550nm ± 20nm), Red (660nm ± 20nm), Red Edge (735nm ± 5nm) and Near Infrared (790nm ± 20nm). This camera is pieced together with a handmade UAV (Setup on Figure 1) that flies over the cane crops while the Parrot Sequoia takes photos.

Future Steps

Using the information provided by the camera, we can make use of various indicators of plant's health such as the NDVI. (Normalized Difference Vegetation Index)

$$NDVI = \frac{NIR - VIS}{NIR + VIS}$$

NIR: Near Infrared band
VIS: Red-visible band

These calculations are made per pixel, and the result varies between -1 and 1. it is zero when there are no green leaves, so there is no vegetation. To apply NDVI, different softwares are used, such as PIX4D AG.

Conclusion

- Image processing can help to identify diseases in sugarcane, especially those that were caused by pests.
- Multispectral images helps to compare results obtained with photoacoustic method implemented in scaled conditions in a laboratory.
- These diseases can be identified by the human eye, but it makes the work long and imprecise (especially in large cultivation areas). The implementation of these methods streamlines the detection of the diseases and makes it certain.

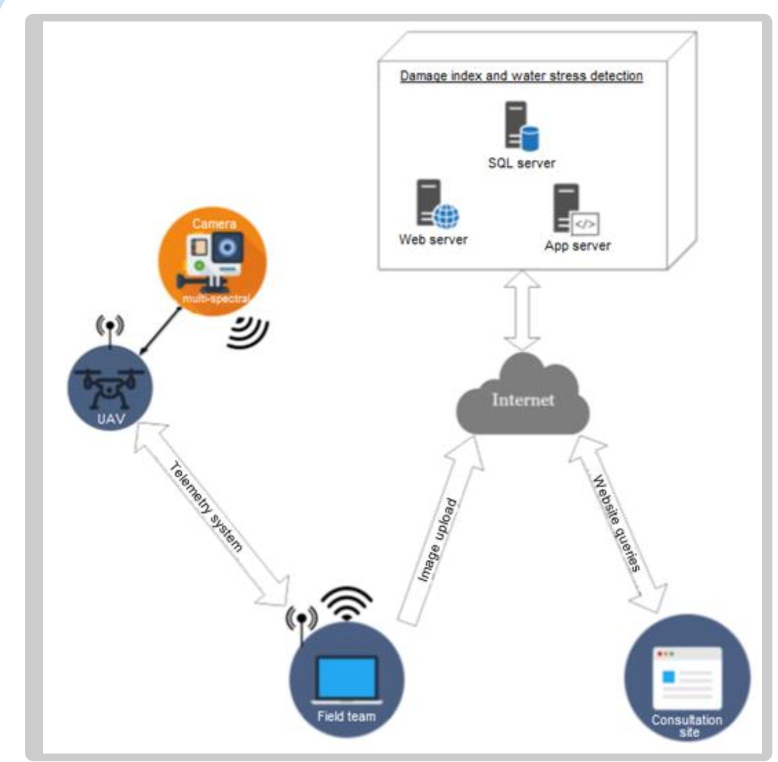

Figure 1. Multispectral System Architecture

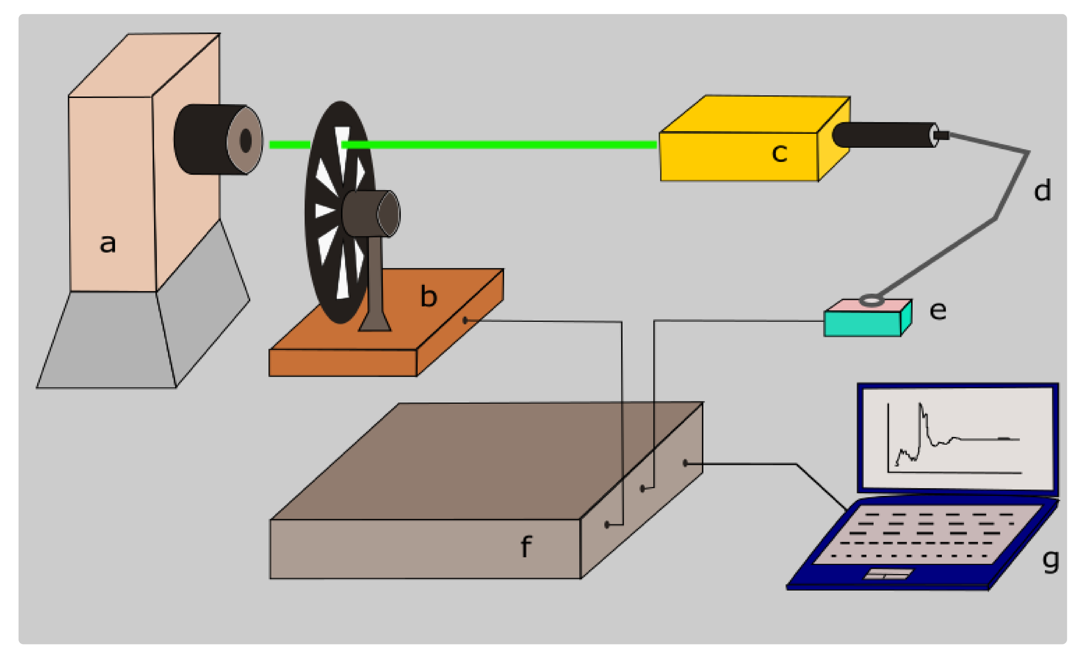

Figure 2. PAS experimental setup. a) Xenon lamp, b) chopper, c) monochromator, d) optical fiber, e) photoacoustic cell, g) personal computer, f) lock-in amplifier

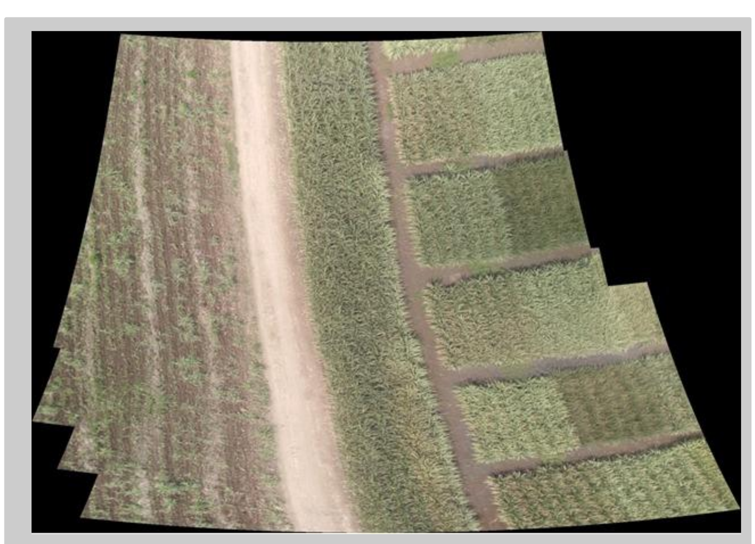

Figure 3. Cane crop orthomosaic from Ingenio El Potrero, in Veracruz, México.

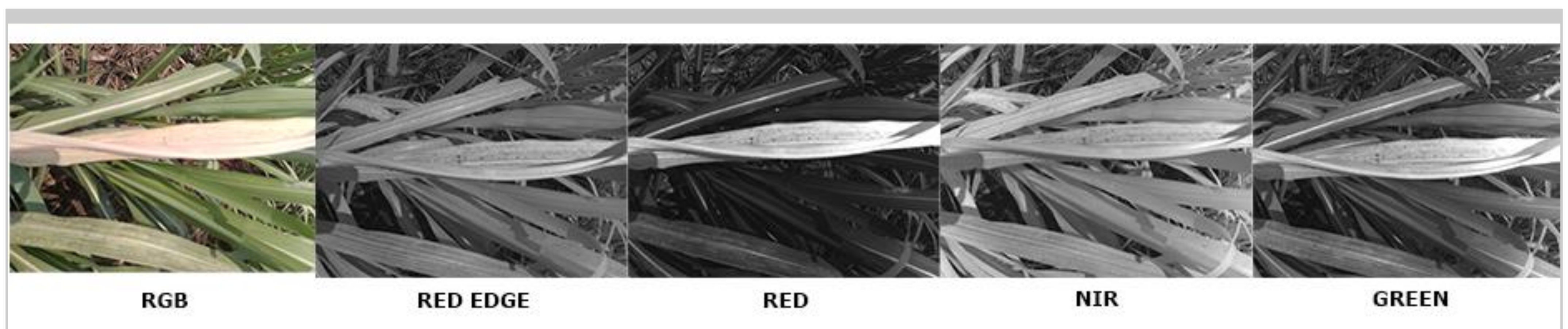

Figure 5. Images taken by the Parrot Sequoia in its different wavelength bands.

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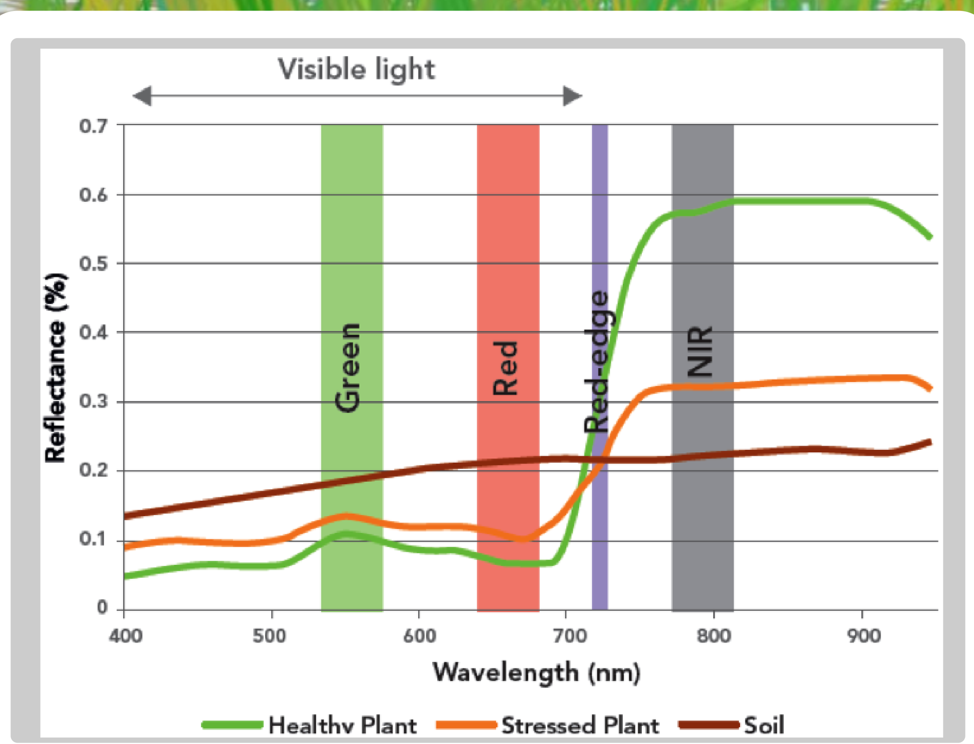

Figure 6. Reflectance on healthy plant, unhealthy plant and soil in the camera's wavelength bands.

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