HYPERSPECTRAL DATA FOR PREDICTION OF LEAF NITROGEN CONTENT IN SUGARCANE

Peterson Ricardo Fiorio

Higher School of Agriculture "Luiz de Queiroz" / University of São Paulo (ESALQ/USP)

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Nitrogen is an essential nutrient for crop production, interacting in a very complex system with environment, so its monitoring is therefore important, both economically as well as environmentally.

There is wide variation in the literature regarding the best dose to be applied in sugarcane, and these differences are directly related to the variety, soil type, and area and cropping system. Thus, the need to develop a tool to determine the nutritional status of sugarcane in different growing conditions is evident, in order to minimize costs, maintain or increase productivity without impacting environmental integrity.

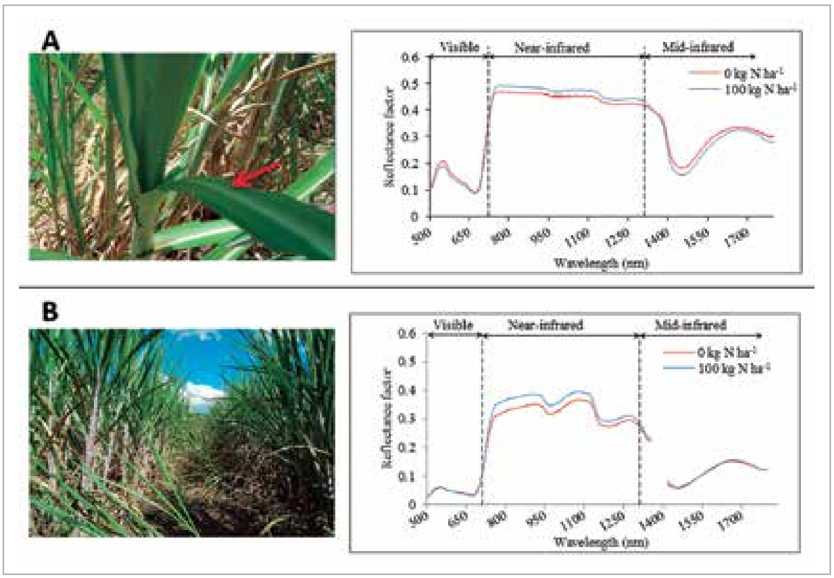

Figure 1. Responses of spectral reflectance of sugarcane at leaf (A) and canopy (B) level, grown on sandy soil, 2013-2014 harvest, using different doses of Nitrogen: stressed (0 kg N ha^{-1}) and unstressed (100 kg N ha^{-1})

As has been noted, the use of remote sensing has expanded in agricultural sciences, providing a useful tool to monitor and manage such activities, including the nitrogen fertilizer administration on crops.

The spectral behavior of sugarcane, through the reflectance curves, makes it possible to estimate various parameters based on the overall condition of the plant. Each range of wavelength yields a different spectral response curve that allows us to predict some physiological states. Therefore, a study on monitoring nitrogen in the culture of sugarcane using hyperspectral sensors is necessary.

Evaluations are performed at different growth stages of sugarcane in a permanent plot of land used for field experiments of São Paulo Agency for Agribusiness Technology, which studies effects of different nitrogen doses in some sugarcane varieties. Spectral readings are held of leaf and canopy; leaves (+1) area collected and sent to laboratory for leaf analysis to determine nitrogen content. These data will be used to generate spectral models of multiple linear regression to predict the leaf nitrogen content, thus detecting the wavelengths that are more related to the plant nitrogen status.

This study aims to show the results that may guide future applications of spectral data to monitoring sugarcane nitrogen fertilization, as new research and development of dedicated sensors for the culture.

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

The project consists in the temporal analysis of the sugarcane (*Saccharum spp. L.*) leaf and canopy spectral behavior in different production environments, under the effect of different nitrogen doses. In 2013-2014 harvesting, the precipitation of several months was lower than the historical average recorded which may influence the crop growth, and consequently the reduction of leaf area, due to the provision of smaller amounts of water during the early growth stages, increasing stress in plants in all treatments with different nitrogen doses.

Preliminary results have shown a difference in the spectral behavior of sugarcane leaves, when average curves were compared between the stressed and unstressed treatments in the different environments. The visible spectral region (400 to 700 nm) of unstressed leaves curves has showed lower reflectance values with opposite behavior near-infrared region (750 to 950 nm).

As the concentration of pigments such as carotenoids, xanthophylls, and anthocyanins cause variations in the visible spectral region, the stressed plants tend to turn clear yellowish-green foliage, while vigorous plants leaves turn to shades of dark green.

For canopy spectral behavior analysis, biometric variables are compared to the average of spectral curves, showing that it is possible to establish meaningful relationships between agronomic variables of culture and the spectral variables obtained by remote sensing; whose spectral parameters can describe the conditions of vigor and development of sugarcane.

Although the canopy spectral curves are more susceptible to interferences from external factors (climate, plant architecture, soil and others) during the collection of data, these curves showed the same pattern of leaves spectral curves measured in a controlled environment.

For both curves, the same tendency regarding the leaf nitrogen content was observed, wherein the stressed plants (0 kg ha^{-1}) have showed a higher reflectance intensity in the red region (660nm) and lower reflectance in the near infrared region (840nm); and unstressed plants (100 kg N ha^{-1}) had the typical curve of healthy vegetation, with lower reflectance intensity in the red region and higher in the near infrared region.

MAIN PUBLICATIONS

Demattê J AM, Campos RC, Alves MC, Fiorio PR, Nanni MR. 2004. Visible-NIR reflectance: a new approach on soil evaluation. *Geoderma*. **121**: 95-112.

Demattê J AM, Sousa AA, Alves MC, Nanni MR, Fiorio PR, Campos RC. 2006. Determining soil water status and other soil characteristics by spectral proximal sensing. *Geoderma*. **135**: 179-195.

Fiorio PR, Demattê J AM. Orbital and laboratory spectral data to optimize soil analysis. 2009. *Scientia Agricola*. **66**: 250-257.

Fiorio PR, Demattê JAM, Nanni MR, Formaggio AR. 2010. Diferenciação espectral de solos utilizando-se dados obtidos em laboratório e por sensor orbital. *Bragantia*. **69(2)**: 453-466.

Fiorio PR, Duarte SN, Rodrigues GO, Miranda JH, Cooke RA. 2012.Comparação de equações de chuvas intensas para localidades do estado de São Paulo. *Engenharia Agrícola*. **32(6)**: 1080-1088.

Nanni MR, Demattê JM, Chicati ML, Fiorio PR, Cézar E, Oliveira RB. 2012. Soil surface spectral data from Landsat imagery for soil class discrimination. *Acta Scientiarum*. **34**: 103-112.

Martins JA, Fiorio PR, Demattê JAM, Miranda JH, Lelis Neto JA. 2014. Sensoriamento remoto na determinação de atributos de um Nitossolo sob aplicação de vinhaça. *Revista Brasileira de Ciência do Solo*. **38**: 959-971.

Fiorio PR, Demattê JAM, Nanni MR, Genu A, Martins JA. 2014. *In situ* Vis-Nir Sensors on the soil class discrimination along transcects: a new view on soil evaluation. *Revista Ciência Agronômica*. **45(3)**: 433-442.

Peterson Ricardo Fiorio

Escola Superior de Agricultura "Luiz de Queiroz"
Universidade de São Paulo (USP)
Departamento de Engenharia de Biossistemas
Avenida Pádua Dias, 11
CEP 13418-900 – Piracicaba/SP – Brasil

+55-19-3447-8531, ramal 8531
fiorio@usp.br