USING VISIBLE NEAR-INFRARED (VNIR) TO ASSESS SELECTED NUTRIENTS IN SOILS OF THE SAHEL.

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Introduction

Food Production Decline

- Rapid population growth in Sahel
- Increased land requirement
- Short fallow depletes soil fertility
- Decreases crop yields

Possible Alternatives

- Invest in management practices to sequester atmospheric CO_2 and store it in soils.
- Need a laboratory method to better quantify and manage soil properties in the Sahel region.

Hypothesis

Visible near infrared spectroscopy (VNIR) can be a rapid, reliable and cost-effective alternative to chemical methods for the determination of nutrients in soils in the Sahel.

Objective

Explore the possibility of using VNIR spectroscopy as a method for measuring selected properties in tropical soils of the Sahel.

Material and Methods

Calibration samples:

- Fansirakoro 84 soil samples (0-20 and 20-40 cm) in Mali (2006).
- Konobougou 121 soil samples (0 -20 and 20 - 40 cm) in Mali (2006).

Validation samples:

- Fansirakoro-Mali: 41 soil samples at depths of 0-20 and 20-40 cm in 2004
- Nioro du Rip-Sénégal: 60 soil samples at depths of 0-20 and 20-40 cm in 2006.

Methods:

- Organic carbon (OC) was determined by combustion (LECO CNS 2000)
- Fe, Al and phosphate were determined by extraction (ammonium oxalate)
- Particle size distribution was determined using the pipette method.
- Soil samples were scanned using an Agrispec™ spectrophotometer (ASD 350-2500). The VNIR spectra of the sample (n=306) were recorded in 1 nm increments ranging from 350 to 2500 nm.

Results and discussion

- The spectra were obtained by plotting reflectance against wavelength.
- These spectra are characterized by 3 major absorption bands at 1400, 1900 and 2200 nm.
- Samples with more clay showed lower reflectance and stronger absorption deeps (Figure 1).

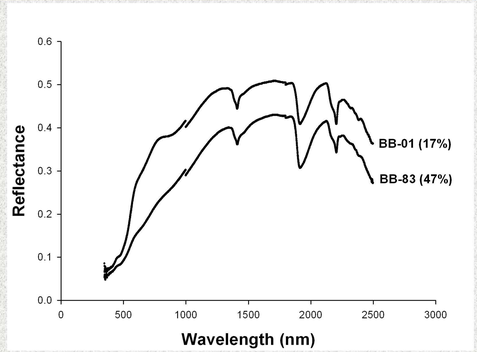

Fig. 1: Soil spectra

Calibration: Develop a predictive relationship between the spectral reflectance and the chemical properties of interest.

- The RPD is the ratio of standard deviation of measured values of soil properties in the calibration set to the standard error of calibration.

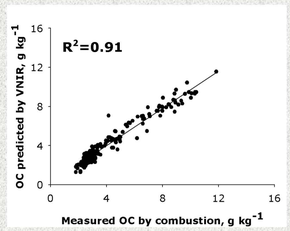

Fig.2: Calibration for OC

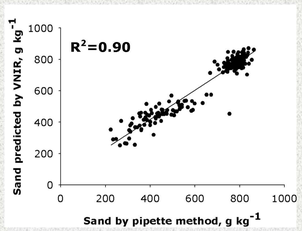

Fig. 3: Calibration for sand

- Accurate calibration for organic carbon and sand with RPD=3.37, and RPD=3.20, respectively, which is considered very good.

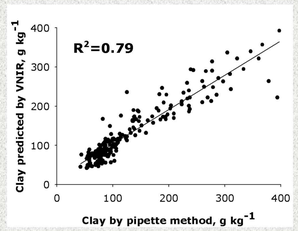

Fig. 4: Calibration for clay

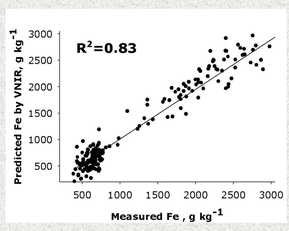

Fig. 5: Calibration for iron, Fe

- Calibration was lower for clay and iron (Fe) with RPD=2.19 and 2.42, respectively, which is considered good.

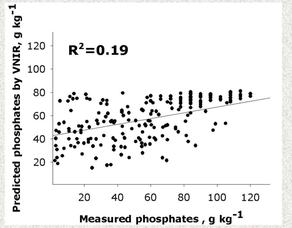

Fig. 6: Calibration for phosphate

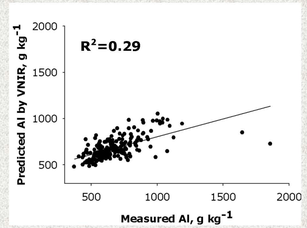

Fig. 7: Calibration for Aluminum

- Calibration was very poor for phosphate and Al with RPD=1.10 and 1.19

Validation: Comparison of predicted OC in samples from Mali-2004 and Senegal 2006 against measured OC using calibration model of 2006 samples.

- Prediction Error: Root Mean Squared Error (RMSE)
- Bias: ME = $\Sigma(X_{pred.}-X_{obs.})/n$ (-) indicates an underestimation.

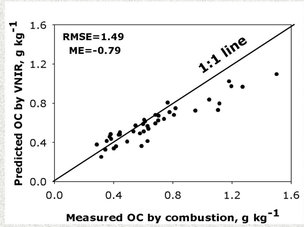

Fig. 8: Validation for Mali-2004 Samples.

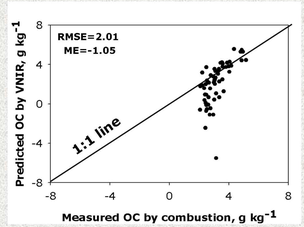

Fig. 9:Validation for Sénégal-2006 samples.

Conclusion

- Except for Al and phosphates calibrations of OC, sand, Fe and clay were accurate.
- Validation results indicated an accurate estimate of Mali-2004 samples in the range of 2.5 to 9 g kg^{-1} and less accurate for Sénégal-2006 samples which were out of the range of calibration of Mali-2006 samples.
- VNIR is a potential alternative to existing laboratory methods for assessing soil properties, however the calibration ought to capture a larger variability of soils of the Sahel.

References:

1. Piéri, C. 1989. Fertilité des terres des Savanes. Bilan de 30 ans de recherche et de développemnt au Sud du Sahara. Paris (France), CIRAD/Ministère de la Coopération et du Développemnt: 444 p.

2. Duckworth, J., 2004. Mathematical data processing. P. 115-17. In C.A. Roberts, J. Workman Jr. and J.B. Reeves III (ed.) Near infrared spectroscopy in agriculture. Agronomy No 44. ASA, CSSA, and SSSA, Madison, WI.

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