Large scale prediction of soil properties in the West African yam belt based on mid-infrared soil spectroscopy

MSc thesis
in agroecosystem science
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Soil sampling and chemical analysis, fundamental principles of mid-IR spectroscopy and PLS regression

In July and August 2016
a total of 80 soils (1 composite sample per f eld) were collected in **80 yam f elds**, 20 per landscape (10km x 10km).

Soil sampling in Côte d'Ivoire and Burkina Faso

14 reference soils from Liliyo were provided by ICRAF

Soil chemical analyses

Mineralogy
Total Fe, Si, **Al**, K, Ca, Zn, Cu, Mn

Organic matter
Total **C, N**, S, and P

Plant nutrition
Resin extractable P, DTPA Fe, DTPA Zn, DTPA Cu, DTPA Mn

Mineralogy and plant nutrition
pH; exchangeable K, Ca, Mg, Al; **CEC**, Base saturation

Chemical data were joined with mid-IR spectra.

94 soils and 25 target variables

Partial least square (PLS) regression

Model validation

Model interpretation

Mid-IR spectra were averaged (3 replicate scans) and Savitzky-Golay f ltering was used as pretreatment.

Pretreated spectra were mean-centered and scaled prior to PLS regression analysis.

mid-IR diffuse ref ectance fourier transform spectroscopy

All soils (n = 94) were milled and scanned in the Alpha spectrometer using 3 scans per sample.

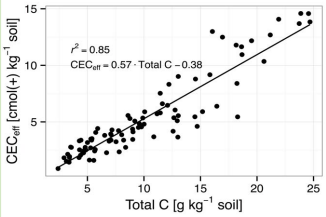
Background and main objective

Yam (*Dioscorea* sp.) yields are low and soil fertility is decreasing across West Africa.

The goal was to develop a mid-IR spectroscopy-based soil database and validated models to assess innovative nutrient management strategies for yam.

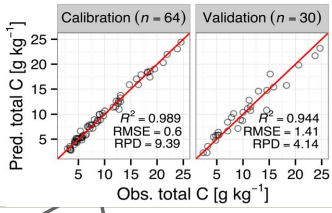
Soil fertility status: best predictions by mid-IR spectroscopy and PLS regression modeling

CEC in tropical soil is mostly determined by soil organic C



Related to soil organic matter

Soil fertility and yam productivity in West African yam belt is limited by low organic C

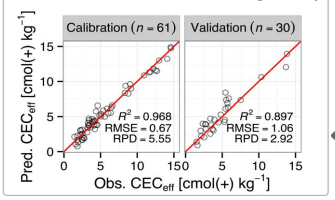


Range of observed and predicted values is well covered in validation and calibration data sets.

PLSR models gave very accurate predictions for total C, exchangeable Ca, effective cation exchange capacity (CEC); total N, K, Ca, and Al.

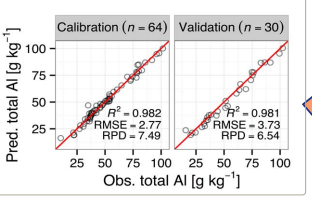
The following properties are proposed for screening high vs. low values (R-squared > 0.5): Total Si, P, S, Zn, Cu, Mn; pH; exchangeable Mg, DTPA Fe, DTPA Cu.

Effective Cation Exchange Capacity



Stabilisation of soil organic matter by clay and iron oxides

Related to texture



Aluminium is positively related to clay and iron oxide content

Spectral model predicted total aluminium can be used as alternative for texture

All 25 models were validated using an independent validation set (Kennard-Stones sampling algorithm).

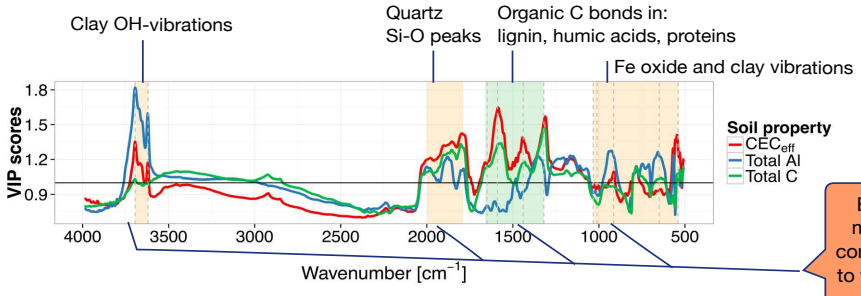
Key f ndings and impacts

Predictions can be used for quantif cation

Accurate predictions (R-squared > 0.8) were obtained for **total C, total N, total Fe, total Al, total P, exchangeable Ca, and effective cation exchange capacity**.

For the selected sites the developed mid-IR spectroscopy library will be used as fast and cost-effective prognostic method for **soil fertility monitoring and assessment** across the yam production chain.

Soil composition – property relation: spectral model assignments



Both features from mineral and organic components contribute to the prediction of soil properties

Spectral predictors were identif ed that **matched** known mid-IR peaks of structural organic C, quartz, kaolinite, and iron oxide bonds described in the soil spectroscopy literature. Humic acid absorption peaks are represented in both total C and cation exchange capacity models. This suggests that spectroscopy modeling is able **to track soil fertility status changes due to innovative and sustainable nutrient management strategies.**

PLS regression modeling technique in combination with mid-IR spectroscopy is therefore considered as **f ngerprint method** that has the potential to improve the understanding of both **soil composition and its mechanistic relations to soil processes and properties.**

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