Prediction of Selected Soil Carbon Enzymes and Properties in a Diverse Population of Ohio Soils Using Near Infrared Reflectance Spectroscopy Analysis

Warren A. Dick[a]*, Basanthi Thavamani[a], Shannon Conley[a], Aditi Sengupta[a#] and Robert Blaisdell[b]
[a]The Ohio State University-OARDC, Wooster, OH, U.S.A., [b]Texas A&M University, College Station, Texas, USA
*Corresponding Author, Email: dick.5@osu.edu [#]Presenting Author

Abstract

A Near Infrared Spectroscopy (NIRS) method was used to predict soil organic carbon and amino sugar concentrations, and β-glucosidase and β-glucosaminidase activity in 184 diverse soils of Ohio. The measured variable values were calibrated to NIR spectral data with partial least squares regression analysis. The multivariate models developed were validated using the full cross validation method and the test set method with a test set size of 50 samples. Statistical analysis of the spectral data was done using the multivariate analysis software Unscrambler 8.0 (CAMO Inc). The first differential transformation of the NIR region (1100-2498 nm) gave good results. The NIRS method predicted well the organic carbon (OC) and amino sugar concentrations in soil (R^2 was 0.91 for OC and 0.90 for amino sugar). The enzyme activity values were also well predicted (R^2 was 0.82 for both soil β-glucosidase and β-glucosaminidase enzyme activity).

Advantages of NIRS Analysis

- Rapid assessment of soil properties
- Nondestructive to samples
- No use of hazardous chemicals
- Simultaneous measurement of variables
- Precision of analysis
- Simple sample preparation

Methods

184 soil samples from Ohio → Air dried, passed through 2 mm mesh, stored at room temperature

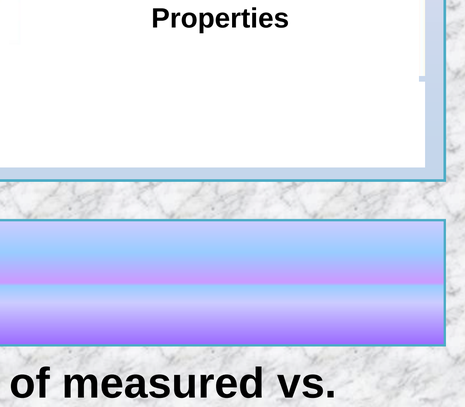
Soil Chemical Analysis:

- Organic carbon content by loss-on-ignition (LOI)[1]
- Amino sugar content by Illinois Nitrogen Soil Test[2]
- β-glucosidase activity[3]
- β-glucosaminidase activity[4]

Soil Spectrum Analysis:

- NIR reflectance values
- Spectral data preprocessing
- Model development

Multivariate Model Development



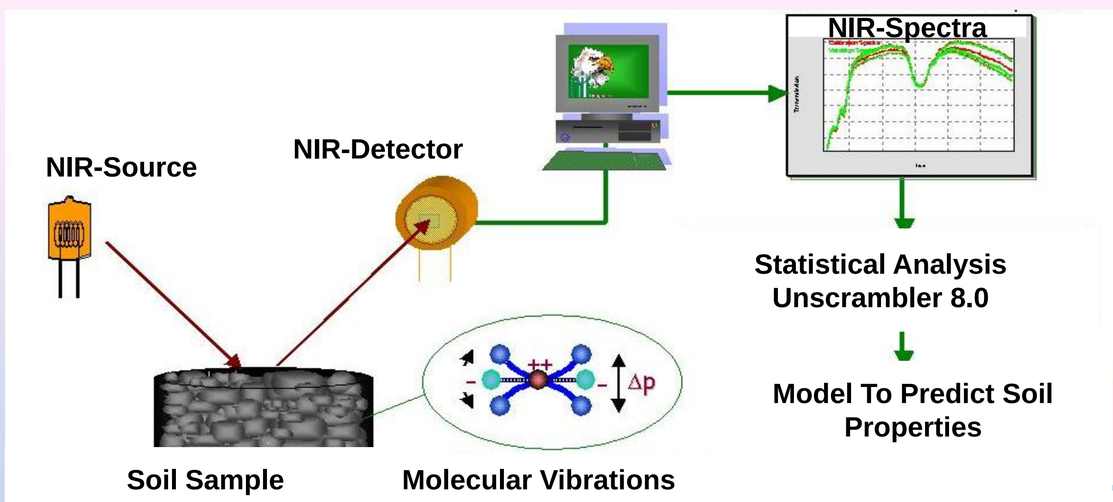


Figure 1. Schematics of soil spectrum analysis

Results

Soil Chemical Analysis

Organic Carbon Content

Values ranged from 1.1-127 g/kg soil with narrow concentration range of 10-30 g/kg soil for 73% of the samples.

β-glucosidase Activity

Values ranged from 0.3-328 mg/kg/h soil with activity levels of 83% of the samples well distributed over a range of 0-120 mg/kg soil/h.

Amino Sugar Content

Values ranged from 9.04-614 mg N/kg soil with concentration range of 100-380 mg N/kg soil for 92% of the samples.

β-glucosaminidase Activity

Values ranged from 0.3-116 mg/kg/h soil with activity levels of 90% of the samples distributed over a range of 0-70 mg/kg soil/h.

Spectral Data Processing

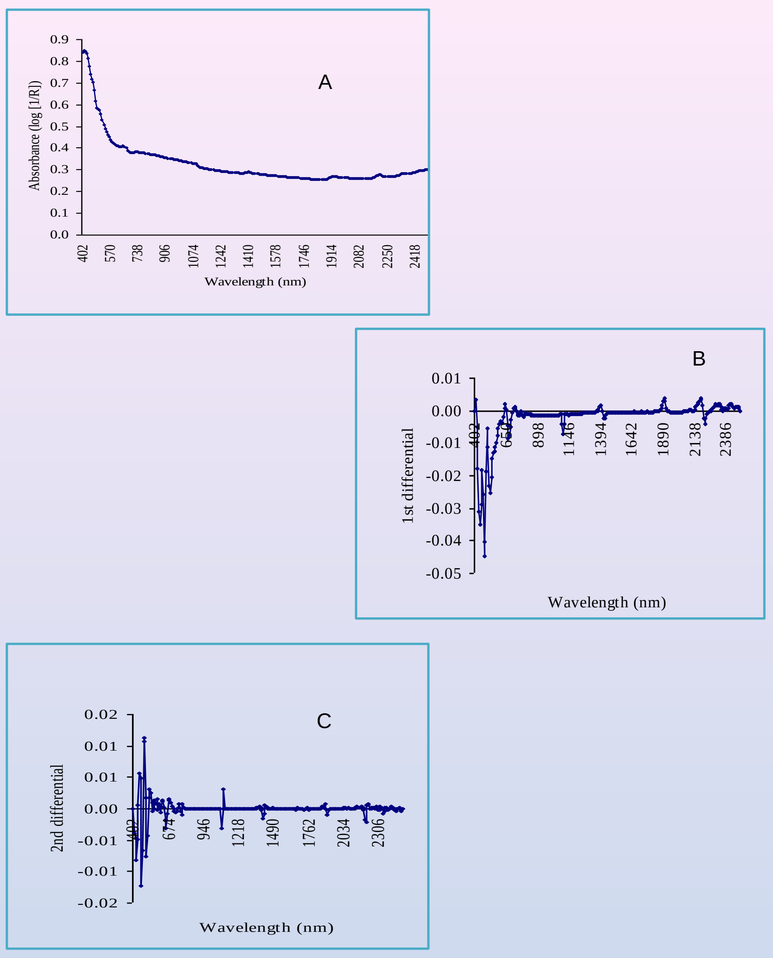


Figure 2. Spectrum of a soil sample. (A) Raw spectral data. (B) First differential of spectral data. (C) Second differential of spectral data.

Correlation of measured vs. predicted values

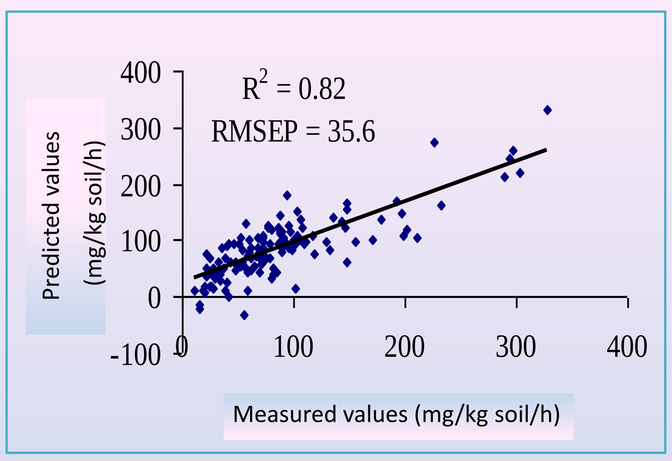


Figure 3. Relationship of β-glucosidase activity as measured chemically and predicted by NIR reflectance spectroscopy method using first differential spectra (1100-2498 nm) and validated by full-cross validation method.

Abbreviations: R^2 = regression coefficient, RMSEP = root mean square error of prediction

Table 1. Correlation Coefficients for the Chosen Calibration Models

Calibration Model	Diff	Cal. R^2	Val. R^2
Organic Carbon	1	0.92	0.91
β–glucosidase	1	0.90	0.82
Amino sugar	1	0.92	0.90
β–glucosaminidase	1	0.82	0.89

Abbreviation: Diff = Differential transformation used, Cal= Calibration and Val= Validation

Discussion

The NIRS method has the potential to rapidly and accurately predict values of carbon-related variables, including the carbon enzymes β-glucosidase and β-glucosaminidase, in soils. The equipment needed is not expensive and the NIRS method can be used where very large numbers of environmental samples need to be rapidly analyzed. Indeed, the prediction equations can be constantly improved as more data points are entered into the correlations between laboratory-measured values and NIRS values.

References

1. Storer, D.A. 1984. A simple high sample volume ashing procedure for determining soil organic matter. Commun. *Soil. Sci. Plant Anal*. 15:759-772.
2. Khan, S.A., R.L. Mulvaney, and R.G. Hoeft. 2001. A simple test for detecting sites that are nonresponsive to nitrogen fertilization. *Soil Sci. Soc. Am. J*. 65:1751-1760.
3. Eivazi, F. and M.A. Tabatabai. 1988. Glucosidases and galactosidases in soils. *Soil Biol. Biochem*. 20:601-606.
4. Parham, J.A. and S.P. Deng. 2000. Detection, quantification and characterization of b-glucosaminidase activity in soil. *Soil Biol Biochem*. 32:1183-1190.
5. CAMO Inc. 2003. The Unscrambler user manual. CAMO Inc., Oslo, Norway.

Acknowledgments

Support was obtained from state and federal funds appropriated to The Ohio Agricultural Research and Development Center – The Ohio State University, Wooster, OH, 44691