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

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Yam (Dioscorea sp.) is an important staple food in West Africa. Fertilizer applications have variable effects on yam tuber yields, and a management option solely based on application of mineral NPK fertilizers may bear the risk of increased organic matter mineralization. Therefore, innovative and sustainable nutrient management strategies need to be developed and evaluated for yam cultivation. The goal of this study was to establish a mid-infrared soil spectroscopic library and models to predict soil properties relevant to yam growth. Soils from yam fields at four different locations in Côte d'Ivoire and Burkina Faso that were representative of the West African yam belt were sampled. The project locations ranged from the humid forest zone (5.88 degrees N) to the northern Guinean savannah (11.07 degrees N). At each location, soils of 20 yam fields were sampled (0–30 cm). For the location in the humid forest zone additional 14 topsoil samples from positions that had been analyzed in the Land Degradation Surveillance Framework developed by ICRAF were included. In total, 94 soil samples were analyzed using established reference analysis protocols. Besides soils were milled and then scanned by fourier transform mid-infrared spectroscopy in the range between 400 and 4000 reciprocal cm. Using partial least squares (PLS) regression, PLS1 calibration models that included soils from the four locations were built using two thirds of the samples selected by Kennard-Stones sampling algorithm in the spectral principal component space. Models were independently validated with the remaining data set. Spectral models for total carbon, total nitrogen, total iron, total aluminum, total potassium, exchangeable calcium, and effective cation exchange capacity performed very well, which was indicated by R-squared values between 0.8 and 1.0 on both calibration and validation. For these soil properties, spectral models can be used for cost-effective, rapid, and accurate predictions. Measures of total silicium, total zinc, total copper, total manganese, pH, exchangeable magnesium, total sulfur, total phosphorus, resin membrane extractable phosphorus, DTPA iron, and DTPA copper were predicted with intermediate accuracy (R-squared of both calibration and validation between 0.5 and 0.8). For these measures, the models can be used to establish a rapid screening in order to distinguish high from low soil fertility status. Generally, soil fertility in West African soils is constrained by low organic C, for example, ranging between 0.2% to 2.5% in this study. The accurate prediction of total soil organic C is an important factor for monitoring soil fertility status. Results of this study showed that soil spectroscopy has a high potential to evaluate soil fertility in the selected locations.