Non-destructive Method of Soil Analysis

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5.1 Introduction

Hyperspectral based Diffuse Reflectance Spectroscopy (HDRS) is a non-destructive method of soil analysis, widely tested for characterization of soil attributes. It is simple, environmental friendly (no use of chemical reagents), non-destructive, rapid, economic and precise. Current remote sensing techniques are quick, real time and cost effective, however, the use of multi-spectral data has the inherent limitation of spectral resolution and sampling band width which conceals the detail spectral signature. In contrast, hyperspectral data provides ample information on a narrow band width for rapid prediction of important soil properties at a reasonable level of accuracy. NBSS&LUP Nagpur since last three decades is extensively involved in utilization of this modern technique for the betterment of the farming community of the country. Some of the remarkable hyperspectral technology for the management natural resources are standardized by the bureau. These are enlisted below:

5.2 Technology

5.2.1. Soil Spectral reflectance library

The spectral library contains the spectral signature database of major soil types of India (2500 surface soils representing different agro-ecological regions, Fig.1). It is the digital soil catalogue stored in ENVI software (Fig.2) for retrieving information on major soil types. Each spectrum in the spectral library (developed in ENVI) is assigned suitable code so that salient information on soils could be derived. The comparison of the spectral signature of the soil samples that will be collected in any time span of future can be compared easily with the nearest matching spectrum available in the soil catalogue. Based on the comparison of two spectra, one can infer the level of changes or deviations that had taken place in the course of time due to the dynamic nature of soil forming process.

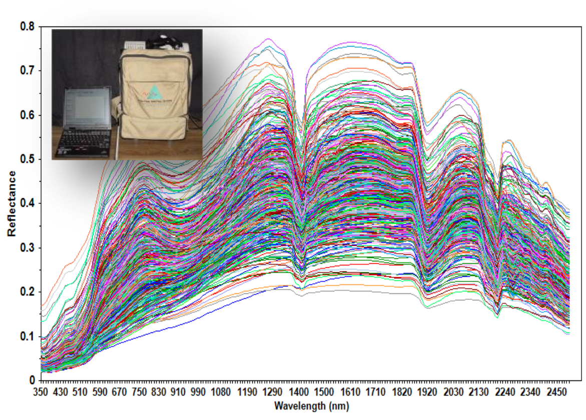

Fig. 5.1. Soil Spectral reflectance curves

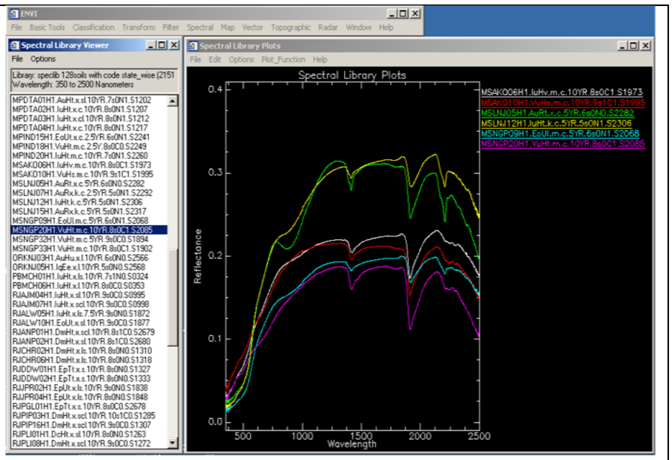

Fig. 5.2. A view of digital soil library developed in ENVI

5.2.2. Hyperspectral remote sensing for predicting Soil organic carbon towards precision farming in Indo-Gangetic plains

Land degradation occurs rapidly as a result of high input agriculture in rice-wheat cropping system of Indo-Gangetic alluvial Plains, a major food growing region of south-east Asia. For sustainability of production system and for preventing/arresting land from further degradation, need of precision farming is felt. This requires rapid site specific information and monitoring of soil organic carbon which is an indicator of soil quality. In this study, visible-near infrared reflectance spectroscopy has been evaluated for rapid prediction of soil organic carbon (SOC). A total of 800 surface soil samples (480 for calibration and 320 for validation) from farmers' field covering Ludhiana, Moga, Gurdaspur and Bhatinda districts of Punjab, India were collected. Reflectance spectra were obtained from air-dried samples (<2 mm size) in controlled laboratory conditions using a Hyperspectral ASD FieldSpec Prospectro radiometer. Part of the same samples was used for SOC determination by Walkley and Black titration method. SOC value in the study area varied from 4.0 to 18.1 g kg^{-1} (mean 7.9 g kg^{-1} and standard deviation of 2.2 g kg^{-1}) in the soil samples. Partial least squares regression technique was used to examine the relationships between SOC and the reflectance spectra. Among 15 spectral transformations used for calibration, SGF-2-3 transformation (transformation to 1st derivative with second order polynomial smoothing with 3 points using Savitzky-Golay filter) was the best for SOC modeling in the soils of IGP. SGF-2-3 transformation recorded the highest validation r^2 (0.81) and RPD (2.30) and the lowest RMSEP (0.116) with 6 PLS factors (Fig. 3). The most important wave lengths for SOC prediction were 460, 470 and 550 nm in the visible and 1400, 1420, 1920, 2040, 2210, 2270, 2320 and 2380 nm in the near-infrared region.

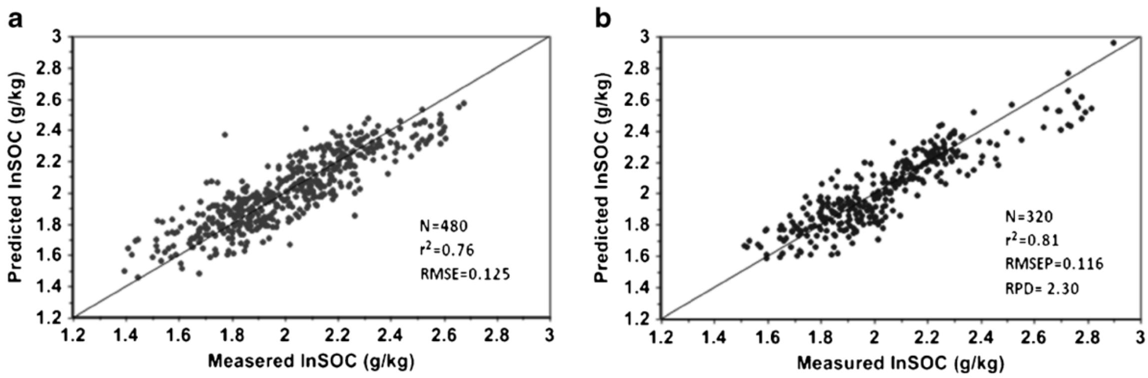

Fig. 5.3 Scatter plot of measured and predicted values of lnSOC (g kg^{-1}) in calibration (a) and validation datasets (b)

5.2.3. Rapid Characterization of Salt-Affected Soil in the Indo-Gangetic Plains of Haryana, India using Visible-Near Infrared Reflectance Spectroscopy

Management of salt-affected soils is a challenging task in the input intensive rice-wheat cropping in the Indo-Gangetic plains (IGP). Timely detection of salt-affected areas and assessment of the degree of severity are vital in order to narrow down the potential gap in yield. Conventional laboratory techniques of saturation extract electrical conductivity (EC_e) and sodium adsorption ration (SAR) for soil salinity assessment are time-consuming and labour intensive; the VNIR (visible-near infrared) reflectance spectroscopy technique provides ample information on salinity and its attributes in an efficient and cost-effective manner. The results indicated that the spectral region between 1390 and 2400 nm is highly sensitive to measure changes in salinity. The developed hyper spectral models explained more than 80 % variability in EC_e, and other salinity related attributes (saturated extract Na^+, Ca^{2+} , Mg^{2+}, $Cl^-$and SAR) in the validation datasets (Fig. 4 and 5).

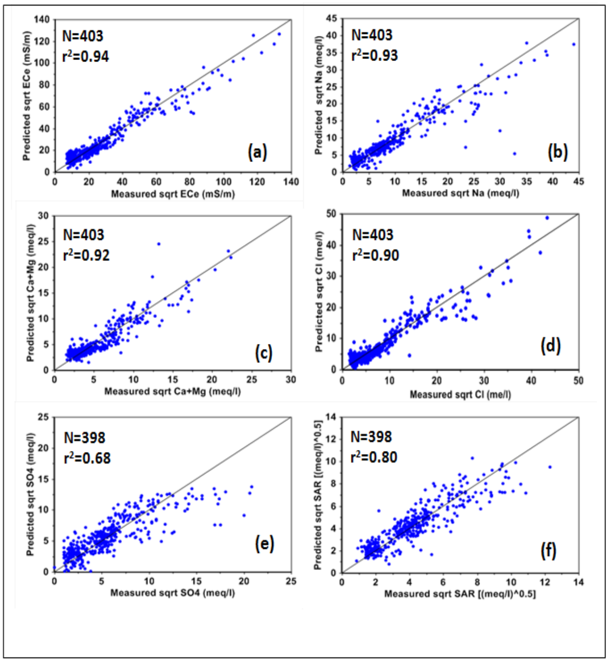

Fig. 5.4 Scattered plot of measured and predicted values (in square root transformation) of saturation extract (a) ECe, (b) Na^+, (c) Ca^{2+}+Mg^{2+}, d) Cl^-, (e) $SO4^{2-}$ and SAR in validation datasets

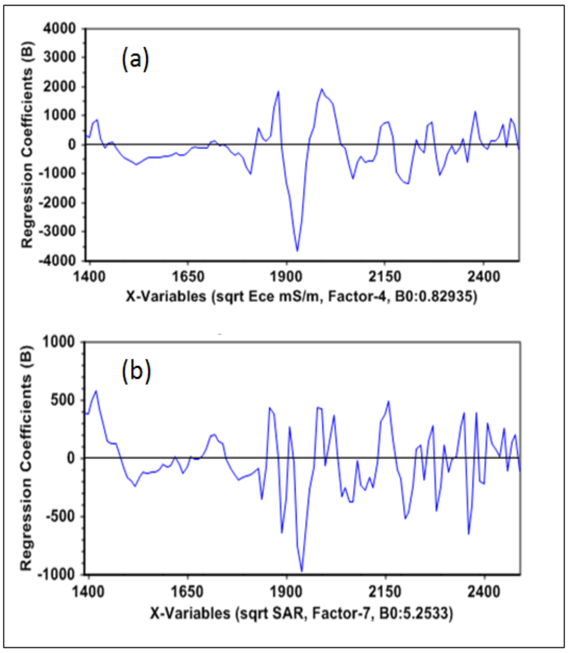

Fig. 5.5 Partial least square regression coefficient for saturation extract ECe (a) and SAR(b) at different wavebands

5.3 Summary

Rapid evaluation of SOC through hyperspectral model are encouraging and expected to be a vital tool for real time evaluation of pre and post-scenarios of soil quality and sustainability under precision farming system. The technology will be very useful in real time monitoring of soils in the spatio-temporal context; enabling the farmers of IGP area to deal with land degradation more effectively and efficiently. The bands identified for different soil attributes namely soil organic carbon and salinity related parameters can be included as such or as ratios or indices in the sensor based application of variable rate inputs as a low cost options for precision farming.