Solution:

Rapid soil assessment using Diffuse Reflectance Spectroscopy (DRS)

Submitter: (ICRISAT)

Solution Overview:

Rapid soil assessment using the Diffuse Reflectance Spectroscopy technique enables the rapid estimation of soil properties. This method delivers soil health results within minutes in a non-destructive manner. It eliminates the use of chemical reagents, making the process safer, more environmentally friendly, and cost-effective. It predicts multiple soil properties simultaneously. A single scan provides information on multiple soil properties, including physical, nutrient, and biological indicators. The approach can be applied in both on-site field settings and laboratory settings, offering flexibility in implementation. It supports immediate, location-specific fertilizer and amendment recommendations based on actual soil conditions.

Key Features & Benefits

Main components and why it is useful? Bullet points summarizing methods, tools, and value added.

The initiative comprises three main components: i) building robust spectral libraries through the collection of diverse soil samples across various ecologies, land uses, and cropping systems for accurate prediction of soil properties using chemometric models; ii) capacity and awareness building through targeted training for farmers and extension workers to interpret soil test results and apply appropriate agronomic practices; and iii) pilot demonstrations to showcase the practical use of crop-specific soil health recommendations.

This approach is helpful as it offers a scalable, low-cost, and rapid alternative to conventional soil testing, enhances fertilizer use efficiency, improves crop productivity and soil health, empowers stakeholders with actionable data, and supports integrated land and water resource planning.

Where It Works and Where It Can Work

Existing and potential target regions, agroecologies, or farming systems. Include examples if available.

DRS holds strong potential across diverse agroecological zones and can be effectively applied at plot, village, and national scales to support comprehensive soil assessment and monitoring. Its ability to rapidly estimate multiple soil properties without the need for chemical reagents makes it ideal for resource-limited settings, while its scalability enables integration into large-scale soil health programs, precision agriculture platforms, and land restoration initiatives.

Evidence & Impact

What results has it shown? Stats, pilot outcomes, or testimonials.

- Demonstrated DRS as a viable alternative to conventional soil testing for smallholder nutrient recommendations. In Uttar Pradesh, the DRS achieved >86% agreement with wet-lab-derived Soil Test Crop Response (STCR) ratings across multiple parameters, with particularly high classification accuracy for EC (>98%), B (>89%), Ca (>81%), and pH (>81%). The study demonstrated that DRS can be utilized not only for property prediction but also for field-level nutrient recommendations, providing a high-throughput and environmentally safe method that eliminates the need for chemical reagents.
- Extending this work across spatial and temporal domains, we evaluated over 1,700 smallholder soil samples collected over a two-year period for 17 different parameters. Our findings confirmed that DRS-based models maintain R^2 values as high as 0.93 for properties such as exchangeable Calcium, among others, even when applied to new sites and periods. The models demonstrated that unseen samples could be predicted with >70% accuracy for 17 tested

soil parameters. Additionally, a composite Soil Quality Index (SQI) derived from DRS data showed strong correlation with crop yield (R^2 = 0.71), supporting its use in productivity-linked soil management

Scalability & Adoption Support

Why it can be scaled and what's needed to adopt it?

Low-cost, adaptable, partner-ready, etc.

DRS is a low-cost, non-destructive, and chemical-free method that enables rapid analysis of multiple soil properties from a single scan. Its portability and speed make it especially suitable for scaling in resource-constrained and decentralized agricultural systems, including those with fragmented landholdings. The method has already proven its ability to handle high-throughput testing, particularly in smallholder farming contexts (Uttar Pradesh), enabling broad coverage with limited infrastructure. Because it does not rely on complex chemical procedures or large laboratory setups, it can be deployed at the plot, cluster, and national levels with minimal logistical burden. Its adaptability makes it relevant not only for standard soil testing but also for precision agriculture, land restoration, and soil carbon monitoring programs.

What's Needed for Adoption

i) Locally calibrated spectral libraries; ii) Training for field technicians and extension agents; iii) Policy recognition as an accepted alternative to lab testing

Partners & Contact Info

Who's involved and how to connect? List of key contact and partners + email / phone.

Dr. Israr Majeed, Phone: +917235988363, Email: israrmajeed.reshi@icrisat.org

Partners: Prof. Bhabani Sankar Das (IIT Kharagpur), Phone: +91-9434025413, bhabani99@gmail.com