SIAC Activity 1.2: Advancing Methodologies for Tracking the Uptake and Adoption of Natural Resource Management Technologies in Agriculture

Title of the project: Hyperspectral signature analysis: a proof of concept for tracking adoption of crop management practices - Gazipur, Bangladesh.

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Workplan

Background and Objectives:

Monitoring the adoption of improved crop management practices is crucial in the impact analysis of research and development and in guiding future research and technology delivery agenda. Tracking adoption of improved crop establishment and management practices is difficult to do using manual surveys that take up much labor, time, and resource. Remote sensing techniques can provide a lower-cost solution. However, very few studies have been conducted on adoption of crop management practices using remote sensing, and researchers have not achieved good accuracy (Chakraborty et al 1997). To improve remote sensing-based characterization for the identification of crop management practices, it is essential to (a) study the spectral response of crops to practices at various physiological stages (Nuarsa et al 2011), and (b) identify the wavelengths in the hyperspectral signatures that best distinguish among practices (Rao 2008).

This pilot study will use a field spectroradiometer, a sensor that can assess the spectral response of crops across a huge range of electromagnetic spectrum, to monitor a range of management practices in a controlled field experiment for rice. This will allow us to assess whether crop establishment methods/management practices can be differentiated through hyperspectral analysis. Information on key discriminatory wavelengths derived from this study will then be applied to hyperspectral remote sensing imagery so that different types of crop management can be detected and, hence, adoption/diffusion can be monitored on a broad geographic scale with high accuracy and low cost.

An example of the ability to discriminate among crop management practices in wheat is shown below (Chandna 2006). Each graph (Figure 1) shows the spectral signature of four different practices at four stages during the season. The figure shows clearly that zero-tillage wheat, along with various residue retention methods, can be identified and differentiated at the early stage of the crop (graph marked “Dec 22, 2005”) between 800–1100 nm wavelengths.

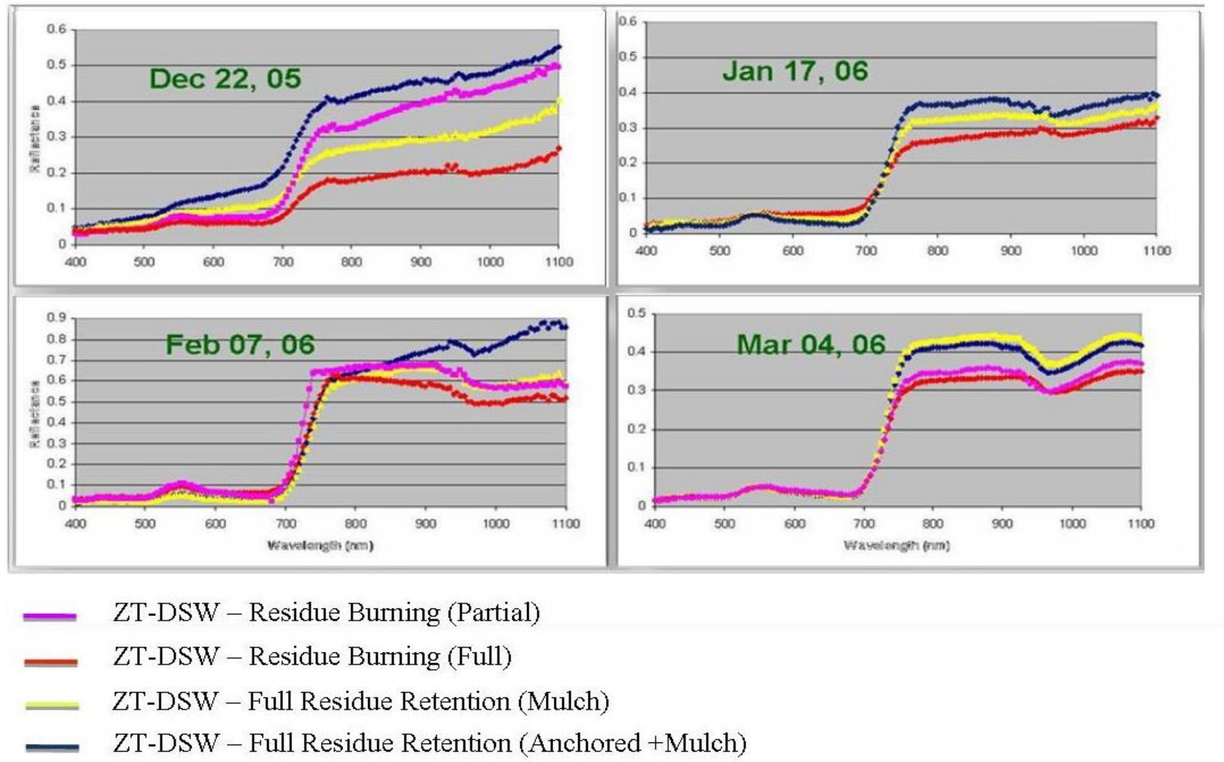

Fig. 1. Spectral signature of four different practices at four stages during the season.

Objectives

1) To test the ability of hyperspectral sensors at field level to discriminate among conventional and improved crop management practices for staple crops by identifying key wavelengths and crop stages, or both, where the discrimination signature is most accurate, reliable, and repeatable.

2) To test for scalability by applying discrimination signatures to hyperspectral remote sensing images over an area where adoption has already been assessed by conventional survey methods.

Scope of Work:

Activities

Activity 1 | Field experiment. A crop experiment will be conducted at Gazipur, Bangladesh, during the aus (early kharif) season from April to September to monitor crop management practices of rice with a field spectroradiometer. A controlled experimental plot will be established using the most popular traditional practices and improved crop establishment/management practices that either enhance soil and water efficiency or conserve these. A random block field layout will be prepared for 2–3 replications of each treatment, with a plot size of 2 × 3 m each.

The experiment will include the following treatments:

- Transplanted rice with traditional methods of irrigation (conventional)
- Transplanted rice with alternate wetting and drying (improved)
- Direct-seeded rice without residue retention (improved)
- Direct-seeded rice with residue retention as surface mulch (improved)

Activity 2 | Field data collection. Spectroradiometric observations will be taken with a PSR-3500 portable spectroradiometer that has a spectral range of 350–2500 nm and a spectral resolution of 3.5–10 nm. This covers a wide range of the ultraviolet, visible, and near-infrared spectra. Spectroradiometer observations with 5–10 nm interval scale (radiance of the reference panel and sample field) will be taken weekly, covering land preparation, all phenological stages of crops, and harvest, to capture the spectral variability on the ground. Reference panel and field sample measurements will be taken every week (during the observations) to avoid the effects of atmospheric conditions and solar angle.

Activity 3 | Data analysis and development of indices. The observed spectroradiometer data will be analyzed to identify the wavelengths and stages when we can best discriminate among different management practices. Various analytical (geostatistical, statistical, and mathematical) techniques will be applied to test and understand the relationship among different segments of the whole spectrum (350–2500 nm), in order to develop new remote sensing-based indexes.

Activity 4 | Test and validation of indices. This analysis of spectral variability among practices at field level will be subsequently applied to hyperspectral remote sensing imagery to detect the same practices at a regional scale. We will obtain NASA Hyperion imagery over the experimental station and over suitable sites where adoption of practices has been previously estimated through technology adoption surveys under CSISA project. (CSISA-BD project conducts farm level technology adoption surveys in CSISA hubs to monitor the adoption of improved crop management practices at farmer fields eg alternate wetting and drying in rice or direct seeding rice.) Hyperion imagery has 220 spectral bands of 400–2500 nm—the same range as the field observations—and has a spatial resolution of 30 m (less than 0.1 ha) and a footprint of 19.8 × 7.7 km, or 15,000 ha. This is sufficient to cover several villages with one footprint at a spatial resolution equivalent to or smaller than typical field sizes. Around 5 to 6 foot prints (images) will be acquired to cover critical phenological crop stages during the AUS season (April to September).

Using the technology adoption survey data of CSISA-BD project, a small cluster of 2-3 villages will be identified where a particular technology has been adopted over 20% area in farmer's fields. The ground coordinates and other details of particular crop management practice will be obtained from CSISA adoption surveys. These ground coordinates (latitude & longitude) and crop data (practice, cultivar type, plating time etc) will be used to develop on-farm spectral response of specific management practice. These spectral responses will be statistically analyzed (regression) to find out the relationship of satellite data and field observations. Identification of specific bands, spectral indices and correction factors will be developed to formulate methodology for detection of crop management practices using remote sensing methods.

The survey results will be used to assess the accuracy and cost-effectiveness of hyperspectral remote sensing. The survey data will be georeferenced to the finest level possible, to map the presence and area, or both, covered by each practice. These results will be compared with the hyperspectral analysis of the same area. The cost of hyperspectral analysis per unit area or per farm will be compared with the cost of surveys using a simple cost-benefit analysis.

Activity 5 | Results and publication. The output of the abovementioned activities (1 to 4) will be a detailed project report. The key findings from the research output will be presented at various national and international platforms among students, agriculture scientists, policymakers, and planners during the meetings and conferences. All major outputs of the proposed research will be published in an international peer-reviewed journal.

Timeline

Activity	**Q1 2014**			**Q2 2014**			**Q3 2014**			**Q4 2014**		
Months	J	F	M	A	M	J	J	A	S	O	N	D
Site selection in Bangladesh/India				■	■							
CSISA data assessment			■	■					■	■	■	
Spectroradiometer purchase			■	■	■							
Hyperspectral imagery order						■	■	■	■	■		
Staff hiring and training				■	■	■						
Field and plot preparation				■	■							
Field data campaign						■	■	■	■	■	■	
Field data analysis								■	■	■	■	
Hyperspectral image analysis									■	■	■	■
Reporting and publication							■					■

Links to larger projects

The project fits within the work of the IRRI Social Science Division on tracking adoption in South Asia (TRIVSA) and to GRISP Theme 5, Product Line 5.2, on spatial analysis for effective technology targeting.

As mentioned above, this study will also leverage results from CSISA project surveys related to the adoption and dissemination of crop management practices in South Asia.

There is also the opportunity to link the results from this proposal to those of the Rice Monitoring Survey: South Asia (RMS-SA), a one-year pilot project that aims to establish a regional rice monitoring system to track diffusion of new varieties. If both of these projects are successful, then we would have a good basis for a longer term investment to track new rice technologies across large areas of South Asia.

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