

EVALUATION OF GROUND HYPERSPECTRAL REMOTE SENSING FOR PRECISE SATELLITE IMAGERY BASED LAND COVER CLASSIFICATION AND FORECASTING OF RICE GRAIN PRODUCTION

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Abstract – Growing population and increasing food demands necessitate the early and accurate estimates of grain production from crop based to now variety based. For which the knowledge of potential discriminates for the rice varieties during satellite imagery classification has become important prior to take satellite imagery. A field based experimental study was conducted in which pure stands of eight rice varieties were raised to maximum tillering stage. Hyper-spectral and multi-angular reflectance was taken from the canopy of rice stands using a portable spectrometer. One nadir and two off nadir viewing angles and wavelength range from 400 nm to 1050 nm were considered for reflectance measurements. Reflectance obtained from the rice varieties were compared for specified viewing angles, wavelength bands and directions. Wavelength range and viewing direction which can potentially differentiate almost all varieties from each other were evaluated as 540 nm to 560 nm and perpendicular plane at considered viewing angles.

Key words: Food demand, land cover classification, bidirectional reflectance, rice varieties, wavelength regions, viewing angles.

1. INTRODUCTION

Evaluating an accurate wavelength region for adjusting spectral resolution is important for maximum inter-variety differentiation that can give an accurate variety based crop land cover classification and subsequent mapping. At varietal level crop land cover identification and management have become important to explain the potential of crop production for timely management decisions. Comprehensive understanding of species compositions and spread is prerequisite for sustainable ecosystem management (Nagendra, 2002). Traditionally species discrimination for land cover classification has been done by exhaustive and time-requiring fieldwork, including taxonomical data and visual computation of percentage cover for each species (Kent and Coker, 1992).

Remote sensing application can help to understand more accurately the composition and distribution of crops at species level within short duration. Moreover, introduction of sensors with high spectral resolution has opened new opportunities for fine tuning differentiation of species (Cochrane, 2000). Hyper-spectral reflectance

based species differentiation has augmented the accuracy of mapping vegetation communities or species. Using hyper-spectral reflectance data researchers are able to differentiate and group the species based on their leaf area or reflectance (Gong, Pu and Yu, 1997; Kumar and Skidmore, 1998). But several questions still exist on the importance of plant canopy reflectance for separating species. Intra species differences in spectra sensitive to various environmental variables (Gausman, 1985; Westman and Price, 1987; Carter, 1993; Carter, 1994; Portugal *et al.*, 1997; Gracia and Ustin, 2001; Smith *et al.*, 2004) and high dimensions of data are other obstacles of concern in this respect.

It is fact that between and within species level differentiation of vegetation using hyper-spectral remote sensing is a complicated process and therefore it is required to have full understanding of all the different aspects before going to a practical application. Varieties which vary in physiological and morphological attributes can differ in light reflectance. Varieties can have differences at their different growth stages and can reflect light differently which can be utilized for their differentiation from each other. While tackling varieties separately for their grain production estimation through satellite or air borne imagery, we usually face the problem of mixed signals (reflectance) from different crop canopies that result into an inaccurate variety based image classification or mapping.

Rice is being grown in the world at large after wheat and corn comprising a share of about 20% in cereal production. Owing to its consumption for increasing population its area of cultivation is increasing and it is being cultivated with little number of varieties which have potentially different yields. Supply of rice grain on sustainable basis is a very important political dispute in many countries leading in accurate distribution and to famine conditions in the world.

The objective of this conducted study was to evaluate the potential of hyper-spectral reflectance and spectral region for rice varieties differentiation.

2. MATERIALS AND METHODS

Eight rice varieties used in the central region of Thailand (Suphanburi 1, Suphanburi 3, Suphanburi 60, Suphanburi 90, Pitsanulok 2, IR 31, IR 35, and Pathumthani 1) were cultivated in different plots. Size of

each plot was 1.5 x 1.5m and rice seedling hills were maintained at 25 x 25 cm spacing. Hyper spectral measurements were taken from the foliage of each rice variety using spectrometer having ability to measure spectral reflectance at each wavelength from 350 nm to 1129 nm. The model of spectrometer is Hamamatsu S390x (MMS) produced by Spectra co-op (Japan) .The spectrometer had a field of view of 22°. The measurements were taken from perpendicular plane from a height of 64.43 cm above the crop canopy to cover a target area of 0.049 m² at nadir and 0.073 m² at maximum angle (45°) (Figure3.2). Spectral reflectance measurements were taken on April 9, 2009 from 11:40 AM to 1:00 PM during which Sun angle varies minimally (<6°) (Table 3.2).

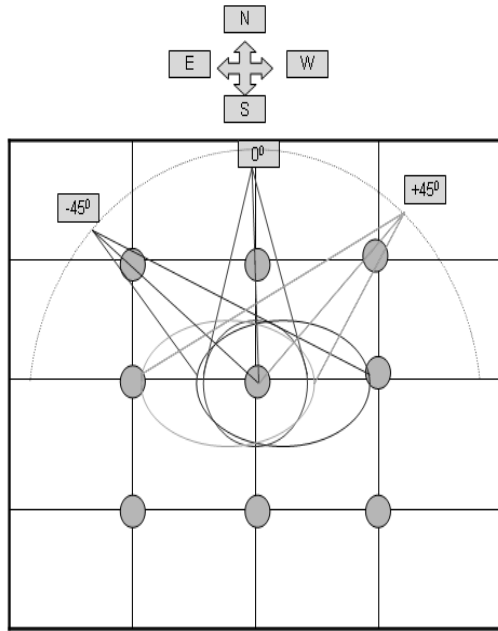


Figure 3.1 Sensor coverage areas over canopy at nadir (0°) and off nadir (45°)

When light reflectance from each direction and at each viewing angle was measured from rice canopy with the spectrometer, a reference measurement was also taken from a barium sulfate coated white panel (reflectance standard) that was kept horizontally at canopy level. Spectrometer automatically calculated the required reflectance after calibrating radiant energy received from leaf with that from white panel (Eq. 1).

$$R_{\lambda, \text{rice}} (\%) = (L_{\lambda, \text{rice}} / (L_{\lambda, \text{panel}} * 100)) \quad \text{Eq. 1}$$

Where $L_{\lambda, \text{rice}}$ is the measured radiance ($[\mu\text{W} \cdot \text{cm}^{-2} \cdot \text{sr}^{-1} \cdot \text{nm}^{-1}]$) for rice canopy at wavelength λ ; $L_{\lambda, \text{panel}}$ is the measured radiance for the calibration panel at wavelength λ ; $R_{\lambda, \text{rice}}$ is the canopy reflectance (%) for rice canopy at wavelength λ .

3.2 Variation of Sun's angle with time on April 9, 2009 from 11:40 AM to 1:00 PM.

Time	Sun angle	Variety Observed
11:40-11:50	78.5 ⁰ to 80.5 ⁰	IR 31
11:50-12:00	80.5 ⁰ to 82.22 ⁰	Suphanburi 90
12:00-12:10	82.22 ⁰ to 83.45 ⁰	Suphanburi 3
12:10-12:20	83.9 ⁰ to 83.39 ⁰	Pathumthani 1
12:20-12:30	83.39 ⁰ to 82.11 ⁰	IR 31
12:30-12:40	83.39 ⁰ to 82.11 ⁰	Suphanburi 1
12:40-12:50	80.11 ⁰ to 80.37 ⁰	Suphanburi 60
12:50-13:00	80.37 ⁰ to 78.37 ⁰	Pisanulok 2

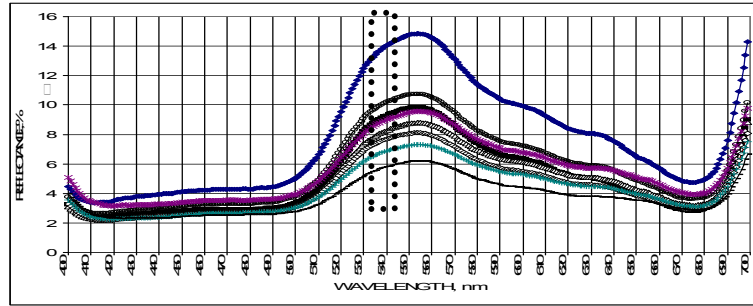
3. RESULTS AND DISCUSSIONS

Considerable differences of reflectance among eight rice varieties were observed for wavelength of green region ranging from 540 to 560 nm at viewing angles 0° (Figure 3.1) and 45° (Figure 3.2) in perpendicular plane. However, reflectance for rest of the wavelength regions could not provide a clear difference among all rice varieties. Out of the entire visible region (400-700 nm) in the spectrum at 45° in perpendicular plane, green wavelength range (540-560 nm) was found suitable as having estimable differences of reflectance among all the eight rice varieties (Figure 3.1).

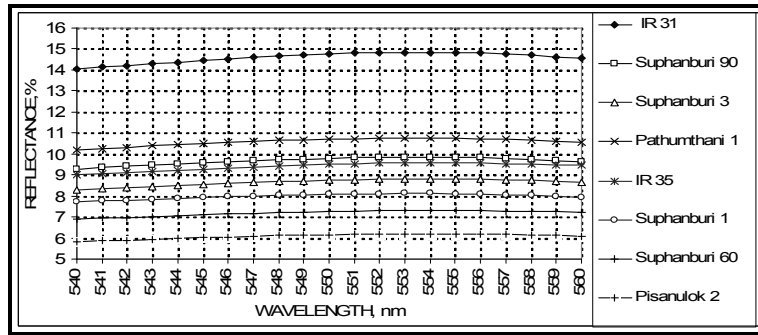
All the eight rice varieties have nearly constant differences of reflectance (separation) from each other for the observed suitable wavelength range. In this wavelength range maximum difference of reflectance (>8%) was observed between pisanulok 2 (lowest) and IR 31 (highest) while minimum difference of reflectance (<1%) was found between IR 35 and suphanburi 90.

At nadir in perpendicular plane, wavelength range that showed differences among all the eight rice varieties was noted from 540 nm to 560 nm (Figure 4.17). For this range minimum difference of reflectance (<1%) occurred between pisanulok 2 and IR 31, between IR 35 and suphanburi 90, between suphanburi 90 and suphanburi 1, and between suphanburi 1 and suphanburi 3, while maximum differences of reflectance (8%) was observed between suphanburi 3 and pathumthani 1.

The evaluated wavelength range and viewing angles (nadir & 45°) come under the coverage of most of the remote sensing satellites (Table 2.2). However, for off nadir viewing, MISR, FORMOST and THEOS for 45°, and for nadir viewing world view (1.6 m), Quickbird (2.4 m) and IKONOS (3.2 m) can be tried. For off nadir viewing choice for spatial resolution becomes narrower towards THEOS (15 m), FORMOST (8 m) and Hyperion (275 m) which can be employed for larger fields of under each variety to cover pixel range.

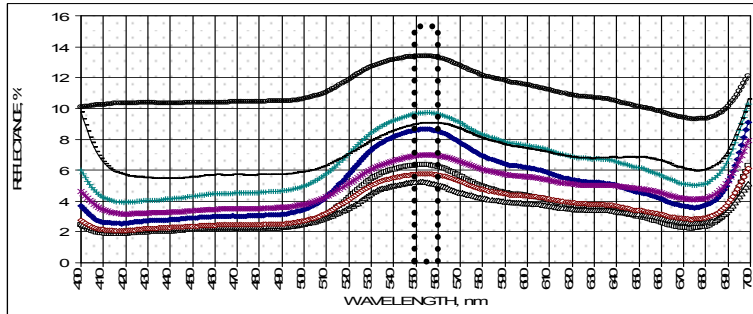


a

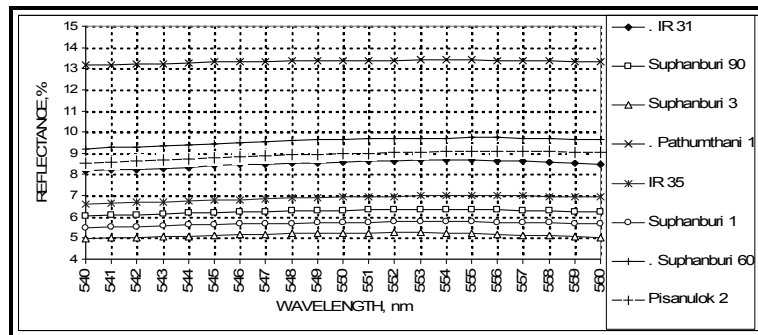


b

Figure 4.1 Reflectance spectra from rice varieties in visible (a) and near infrared (b) regions at 45° .



a



b

Figure 4.1 Reflectance spectra from rice varieties in visible (a & c) and near infrared (b) regions at 45° in perpendicular plane

CONCLUSION

The wavelength ranges and viewing angles which discriminated all of the eight rice varieties from each other were evaluated as 540 nm to 560 nm for nadir and off nadir viewing angle i.e. 45° . However, it is the potential viewing angles and wavelength which can differentiate eight rice varieties simultaneously after taking and classification of the imagery.

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