Nutrient Management in Paddy Fields Using Remote Sensing Technique

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INTRODUCTION

Variable-rate nutrient (N) management is one of the most important activities in precision farming for minimising fertilizer input and maximising yield. Traditional N application methods such as blanket or package fertilizer recommendations over large areas area not efficient because indigenous nutrient supply varies widely in rice fields (Dobermann and White 1999, Olk *et al.*, 1999). According to Peng *et al.* (1996), Balasubramanian *et al.*, (1999) the SPAD chlorophyll meter can be used to monitor plant N status *in situ* in the field and to determine the right time for N topdressing in rice. Field manual measurement of plant N content using the SPAD chlorophyll meter is time-consuming and tedious.

Recently, optical sensing of crop canopy spectral reflectance from ground to aircraft and satellite-based platforms has been introduced to estimate the crop N deficient portions of whole fields, and directing site-specific fertilizer applications for improving the efficiency of N use in cereal grain production (Raun *et al.*, 2002). This remote sensing technique provides a solution to overcome limitations of field-based sampling methods that employ leaf chlorophyll measurements using a meter.

A low-cost diagnostic method that is easy to be used for assessment of nutrient status of plants, based on the estimation of chlorophyll content of leaves using a portable colour video camera and a personal computer has been developed by Shigeto. K and Makoto. N (1998). In the study, relationships between chlorophyll content and various functions derived from red, green and blue wavelengths were examined. Although red-blue and green-blue wavelengths show the highest correlation with chlorophyll content under a limited range of meteorological conditions, the normalised difference (red - blue)/(red + blue) is the most applicable function which can utilise data collected under different meteorological conditions. Based on the result analysis, the accuracy in estimating chlorophyll content from video images could be improved by correlating it with solar radiation data.

Yoder and Pettigrew-Crosby (1995) investigated the spectral characteristics associated with crop N status which have relied upon the observed variation in strength of chlorophyll absorbance in the visible (450-690 nm) region of the electromagnetic spectrum. Daughtry *et al.*, 2000 also found that changes in absorption properties in the "red edge" region (690-730 nm) could be related to changes in plant N status.

The objective of this paper is to predict plant N status using a remote sensing technique for fertilizer management in paddy fields.

METHODOLOGY

Figure 1 shows the flow in the methodology for the prediction of chlorophyll content using a remote sensing technique.

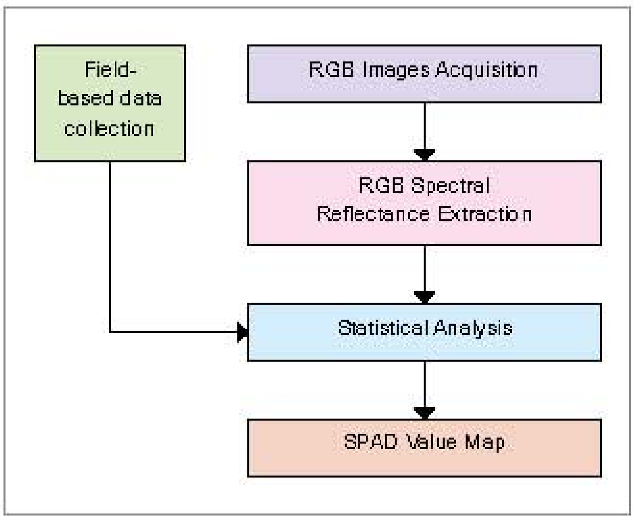

Figure 1: Methodology flow

Field-based Data Collection

Experiments were carried out in the experimental field of FELCRA located in Seberang Perak. Twenty-four squares with a size of 20m X 10m per square were prepared for different fertilizer application (i.e. 0, 50, 100, 150, 175 and 200 kg). A SPAD chlorophyll meter was used to measure the chlorophyll concentration of the rice plants on 3 June 2009 (51-day growing stage) for the centre point of all plots.

The SPAD value for each sample was measured 5 times for the canopy leaves in a 25cm x 25cm aluminum frame square. Average value was used to analyse the relationship between SPAD value and RGB spectral reflectance.

RGB Image Acquisition

RGB images were obtained below cloud canopy by the CropCam unmanned airborne vehicles (UAVs) system at 9:30 a.m. on 3 June 2009 with 280m flying height. The CropCam is a radio controlled model glider plane equipped with a propriety GPS, a miniature autopilot and a digital camera. Hand launched and automatic from take off to landing, the CropCam provides a high resolution GPS based image on demand. The powerful miniature autopilot and GPS did the rest of the navigating in a particular pattern over the field. Both the CropCam and the camera performed automatically to capture GPS based digital imagery. For further analysis, each individual image with latitude, longitude and altitude information was automatic mosaiced by software.

RGB Spectral Reflectance Extraction

Mean RGB values of the plant leaf in the aluminum frame square at the centre point of the 24 experimental squares were calculated by software.

Statistical Analysis

A linear regression analysis method was used to analyse the relationship between SPAD value and RGB spectral reflectance. The 24 samples were separated into 0, 50, 100, 150, 175 and 200 kg fertilizer application categories. Average RGB and SPAD values of 4 readings were calculated for each category. In the regression analysis, a linear model was developed to predict the SPAD value (dependent variable) from the spectral reflectance (independent variable).

SPAD Value Map

The SPAD value prediction model was used to generate a SPAD value map by the software. Three levels (i.e. low, medium and high) of SPAD value maps were generated to provide chlorophyll content status for N management in the study field.

RESULTS AND DISCUSSIONS

Figure 2 shows the RGB mosaiced image for the study area. The relation between SPAD value and RGB spectral reflectance is shown in Figure 3. The highest value of R^2 (0.9348) is R channel followed by G and B channels with values of 0.6787 and 0.175 respectively. This result indicated that a good dependency exits between SPAD value and R spectral reflectance. The linear model developed by the R channel was used to predict the SPAD value for generating the map. Figure 4 shows the SPAD value map generated by the linear model using R channel. This map was used as a treatment map for N management in the paddy field.

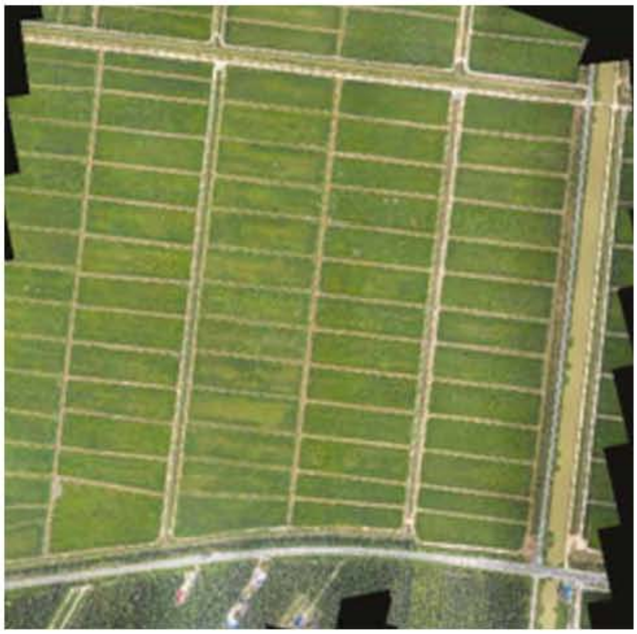

Figure 2: RGB mosaiced image for the study area

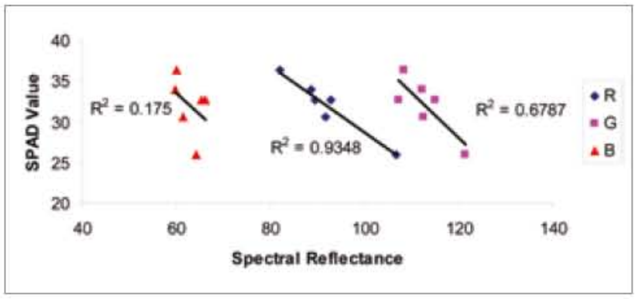

Figure 3: Relationship between SPAD value and RGB spectral reflectance

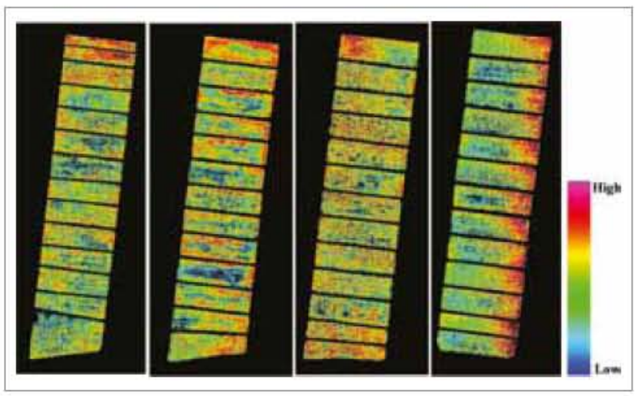

Figure 4: SPAD value map

CONCLUSION

Prediction of the SPAD value based on R spectral reflectance can be accomplished using the image processing technique. R spectral reflectance has a high relationship with SPAD value. A linear model for predicting the SPAD value has been developed for producing fertilizer application maps. ■

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