REMOTE SENSING FOR OIL PALM FOLIAR NITROGEN

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Conventional methods of assessing foliar nutrient content of oil palm are costly, time consuming and involve frond destruction. Recently, the availability of modern technologies such as global positioning system (GPS), remote sensing (RS) and geographic information system (GIS) have created an opportunity to revolutionize the method of assessing oil palm foliar nutrient content. RS is a group of techniques for collecting information about an object, an area or a phenomenon without the need for physical contact. The sensing distances separating the sensor from the object, area or phenomenon can range from a few metres to thousands of kilometres. Methods include aerial photography, radar and satellite imaging. Each object or group of objects reflects a unique spectrum of wavelengths which can be examined by RS. For example, stressed crops reflect various wavelengths of light that are different from those reflected by healthy crops. RS has significant potential to aid oil palm monitoring and detection efforts. Satellite imaging data of Landsat Thematic Mapper (McMorrow, 1995) and SPOT (Lukman and Z. Poeloengan, 1996) has been used successfully to assess oil palm land use hectareage and to map palm age at early stage of growth. In foliar nutrient detection studies, Sembiring *et al.* (2001), Nor Azleen (2001), GopalaPillai *et al.* (1998), Nguen *et al.* (1995) and Jackson *et al.* (1980) reported that RS data could be used to detect phosphorus and nitrogen in wheat, nitrogen in oil palm, nitrogen in corn and major and minor nutrients in oil palm and nutrient deficiencies in sugar cane, respectively.

Nutrients are important to oil palm growth and fresh fruit bunch (FFB) production. Lack of different nutrients will result in different physical properties and appearance of the oil palm leaves (Turner, 1981). It is not possible to measure nutrient levels in oil palm leaves directly using RS. The information can only be inferred from RS measurements. The inferences from measurements require the use of data analysis tools to find relationships between sensor data and actual oil palm foliar nutrient levels measured in the laboratory. Once the relationship is established, the inferences about foliar nutrient content of oil palm over large areas can be made without actual ground-based measurements. This method will reduce the cost of acquiring oil palm nutrient content by minimizing time and labour requirements.

OBJECTIVES

The overall objective of the project is to develop a fast and cost effective tool for monitoring and detecting oil palm foliar nitrogen content using an RS technique. Specific objectives are as follows:

- to verify the suitability of using Landsat TM data for assessing foliar nitrogen content;
- to identify suitable vegetation indexes for detecting oil palm foliar nitrogen content; and
- to develop a model for quantifying nitrogen levels in oil palm leaves.

BENEFITS

This new technique will reduce the cost of assessing oil palm foliar nitrogen content. It will also provide fast foliar nitrogen content information compared to the present conventional method. The development of this technique will enhance the adoption of precision agriculture in oil palm plantation management which is presently not well received by the industry due to its high sampling requirements. The success of this study will help in developing similar techniques to assess other oil palm foliar nutrient contents using RS.

METHODOLOGY

This study was conducted at an MPOB fertilizer trial in Sungai Papan Estate, Kota Tinggi, Johor. The palms were planted in 1980 on Rengam series soil and the fertilizer trial was initiated in 1990. The site was subdivided into 84 plots (*Figure 1*).

A radiometrically corrected Landsat-5 TM 1991 satellite image (*Figure 2*), a digital map of the fertilizer trial plots and foliar analysis data obtained in 1991 were used in this study. *Figure 3* shows the methodology flow chart for developing a foliar nitrogen assessment model using the RS technique. The satellite image was atmospherically corrected using satellite image processing software, Erdas Imagine Version 8.3.1. The satellite image was then geometrically corrected using the topographic map of Pengerang area (Series L7030 Sheet 4651) and then a sub-scene was obtained that included only the study site and the plantation. The digital numbers (DN) for each plot were determined by overlaying the map of the study plots on the geometrically corrected satellite image. Later, the satellite image information was used to compute the reflectance from the DN.

The predetermined foliar nitrogen content of each plot was used to identify and test suitable vegetation indexes to extract foliar nitrogen content information from the satellite image. Three vegetation indexes tested were normalized difference vegetation index (NDVI), soil adjusted vegetation index (SAVI) and atmospherically resistant vegetation index (ARVI). The indexes manipulate the blue, red and near infrared wavelengths of oil palm reflectance to extract the nitrogen content information. From regression analysis, only SAVI gave a positive correlation with foliar nitrogen content (*Figure 4*). Accuracy assessment of the relationship between SAVI and foliar nitrogen and error of the algorithm indicated that the relationship was best described by a linear equation with an accuracy of 91% and error of 4% respectively. The equation used to correlate foliar nitrogen content with SAVI is shown in *Figure 4*. The formulation to derive SAVI is as follows:

$$\text{SAVI} = \frac{(\text{NIR} - \text{R})}{(\text{NIR} + \text{R} + \text{L})} \times (1 + \text{L})$$

Notes: NIR = near infrared wavelength.
R = red wavelength.
L = constant to minimize soil effect.

APPLICATION OF RESULTS

The equation established is site specific. New equations are needed for application of the technique to other areas. SAVI may have an advantage over

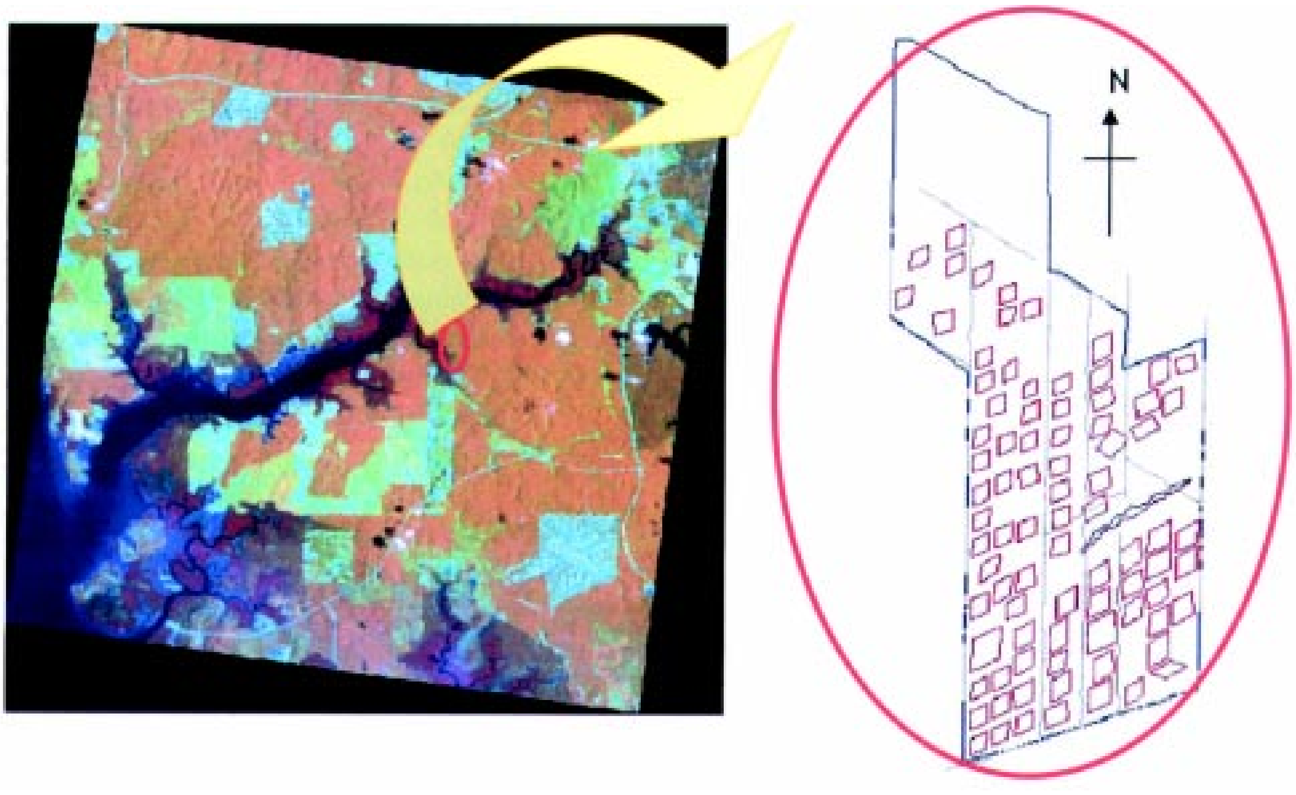

Figure 1. Study site at Sungai Papan Estate on rectified satellite data (not in scale).

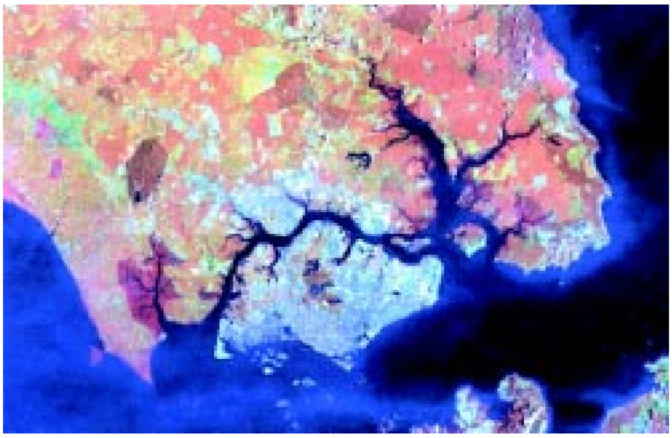

Figure 2. Landsat TM image of Johor in year 1991.

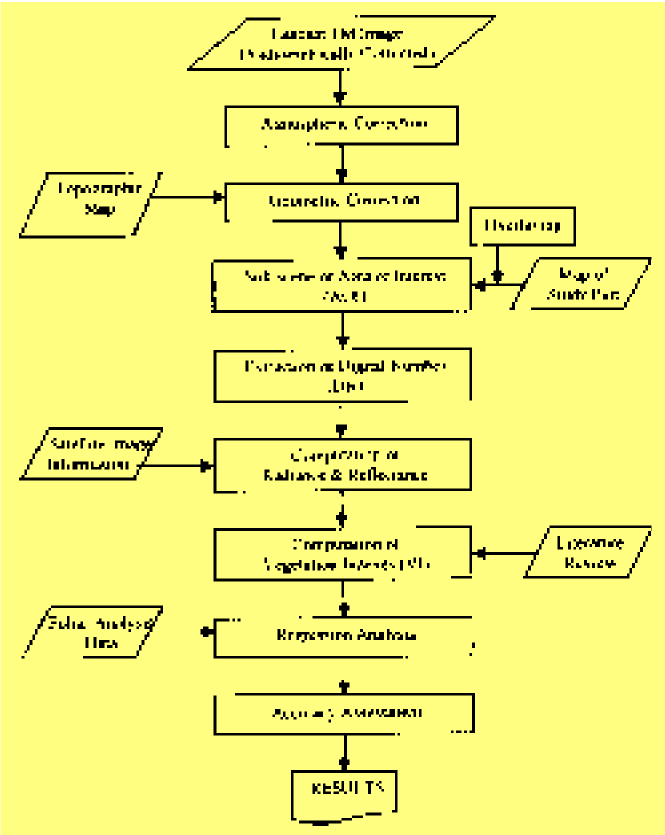

Figure 3. The methodological flow chart for developing a foliar nitrogen assessment model using remote sensing technique.

the other indexes because it can also correlate well with foliage density and can minimize the influence of external factors such as solar and viewing geometry, soil background and atmospheric effects.

CONCLUSION

The RS technique can be used to extract fast information on field data at lower cost with minimum labour requirement. The technique developed to assess the foliar nitrogen content is still at the preliminary stage and more work needs to be carried out to make it more accurate, reliable and sensitive to the small changes in the foliar nitrogen content. Information on the relationship between the biophysical characteristics of the palm and the foliar nutrient content will be very useful for the development of this technique. The availability of higher resolution satellite image will further enhance the development of the technique.

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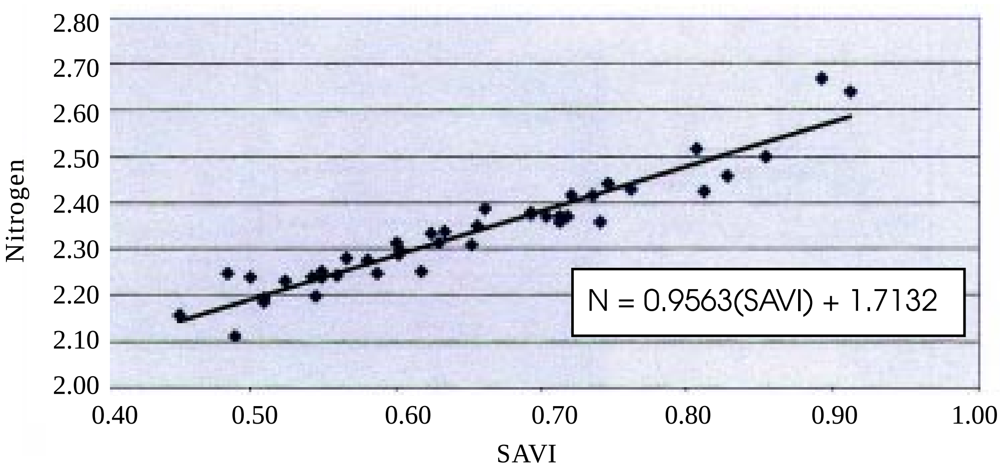

Figure 4. Foliar nitrogen versus SAVI with linear fit line.

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