Detection of Foliar Nutrients of Oil Palm Crop Using Remote Sensing

Ab.Latif Ibrahim, Mazlan Hashim, Abd.Wahid Rasib, Mohamad Idris Ali,
Wan Hazli Wan Kadir, Mohd Razif Sumairi
Department of Remote Sensing,
Faculty of Geoinformation Science and Engineering,
Universiti Teknologi Malaysia,
81310, Skudai, Johor.

Khalid Haron
MPOB Research Station, Kluang Johor

Abstract: This paper examines the capability of remote sensing technique for detecting and quantifying the foliar nutrients of oil palm crop. Study has been carried out in the Malaysian Palm Oil Board (MPOB) Research Station in Kluang Johore, Malaysia. Result of the study shows a strong relationship between measured foliar nutrient and the spectral reflectance measured using spectroradiometer. Model that has been developed can be used to estimate the nutrient concentration in the oil palm plantation at micro level and also at macro-level using appropriate satellite data.
Keywords: Foliar Nutriens, Oil Palm, Spectral Reflectance

1.Introduction

Most of the oil palms crops in Malaysia and also in many other part of the Southeast Asia countries are grown on acidic and low fertility soil (Muterd, 1999). Most of the soils are found to have low to very low contents of nitrogen (N), available phosphorus (P), and exchangeable potassium (K). The lack of adequate mineral availability from most of the topsoils in this region is subjected to leaching due high rainfall. One of the measures taken to overcome problems of nutrients shortages is by applying fertilizer. In fact, one of the major factors that have lead to the advancement of sustainable oil palm yield in Malaysia is due to the application of fertilizer. Currently, the total fertilizer consumption in Malaysia is about one million nutrient tones, and about 62.7% of these total are been used for the oil palm plantation. Large amount of fertilizer usage had contributed to an increased in the production cost, and it was estimated that about 24 percent of the total cost of oil palm production in Malaysia is for fertilizer. An increased in the price of imported fertilizers, together with the current unpredictable economic situation will definitely led to a further increased in the production cost of the oil palm.

Proper management of fertilizer application is therefore very important to ensure efficient uptake, high sustainable yield and maximum benefits from the high expenditure cost.

Application of fertilizer according to traditional recommendation methods usually based on manual analysis of the soil nutritional status in the oil palm plantation through foliar analysis. This traditional method of data collection and analysis found to be laborious, time consuming and also very costly. The development of remote sensing technology especially in term of its application in agricultural practice will be a very useful technique that can helped to improve fertilizer management.

2.Study site and data set

This study was carried out in the Malaysian Palm Oil Board (MPOB) Research Station, Kluang, located in the northern region of Johor (Figure 1). The study area consisted of 16 experimental plots established in June 1984 after the felling of a 23-year-old oil palm plantation (Khalid and Anderson, 2000). All plots with an area of 0.15ha were laid out in a randomized complete block design (RCBD) with two plots representing each of the biomass.

Data used in this study are soil nutrient data from foliar analysis, spectral reflectance from field radiometer and Landsat-5 TM satellite data. The reflectance from leaves taken from frond 17 of palm number 8 from each of the 16 plots was measured using field radiometer. These measurements were carried out in the month of November 2000 and a number of twenty readings were taken from each sample. The radiometer was fixed onto a tripod about 0.7 meters above the leaves that were arranged on the white paper to avoid interferences from other factors. The reflectance from the sample candidates were observed continuously in the wavelengths range of 300 – 1100 nm at an interval of 5nm. However 300 – 400 nm are

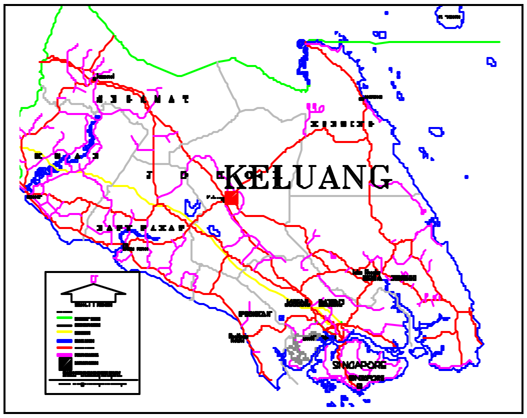

Fig. 1. Location of the Study Area

the ultraviolet region, and reflectance within this region are unexplained, thereby not included in the analysis.

The remaining reflectance were categorized into selected ranges, similar to the range of wavelength of the corresponding band of satellite data to be used in this study, that Landsat-5 band 1 to band 4. After the spectral measurements were done, the same leaves were then taken to MPOB laboratory for foliar analyses. From this analysis, the percentage amounts of nutrients concentration in leaves were obtained.

3. Results and discussion

The spectral reflectance from oil palm leaves and the amounts of nutrients obtained from foliar analysis were examined, analyzed and then evaluations of the relationship between these two variables were made. The basis for this relationship or correlations was established by stepwise multiple linear regression techniques between nutrient concentration from foliar analysis and the reflectance at wavelength which is equivalent to the range of wavelength of band 1 (450-520nm), band 2 (520-600nm), band 3 (630 – 690nm) and band 4 (760 – 900nm) of Landsat-5 (*Lillesand and Kiefer, 2000*e 2). Therefore the reflectances reading from spectroradiometer used for this analysis were first calculated to obtain the mean value of reading within the range of these wavelengths.

Regression models produced demonstrate that, there is a correlation between nutrients and the reflectance, and these indicate that the amount of nutrient (**N, P, Ca, Mg**) can be estimated using the reflectance value at various bands. The concentration of **N** can be estimated using the combination of band 2, band 1 and band 4 of the Landsat-5 TM (r^2 **0.664**) (Eq. 1). The combination of band 2, band 1, band 4, and band 3 of Landsat-5 can be used to estimate **P** (r^2 **0.691**) (Eq. 2). **Ca** can be obtained using band 2 and band 1 (r^2 **0.685**) (Eq 3), and **Mg** using band 4, band 1 and band 2 (r^2 **0.441**) (Eq. 4).

$$n = 2.860 + 11.327\boldsymbol{r}_2 - 8.918\boldsymbol{r}_1 - 0.677\boldsymbol{r}_4 \qquad (1)$$

where, n = % concentration of nitrogen

$\boldsymbol{r}_2$ = band 2
$\boldsymbol{r}_1$ = band 1
$\boldsymbol{r}_4$ = band 4

$$P=0.164+0.486\boldsymbol{r}_2-0.635\boldsymbol{r}_1-0.0308\boldsymbol{r}_4+0.196\boldsymbol{r}_3 \qquad (2)$$

where, p = % concentration of phosphorus

$\boldsymbol{r}_2$ = band 2
$\boldsymbol{r}_1$ = band 1
$\boldsymbol{r}_4$ = band 4
$\boldsymbol{r}_3$ = band 3

$$Ca = 0.666 + 5.224\boldsymbol{r}_2 - 8.361\boldsymbol{r}_1 \qquad (3)$$

where, Ca = % concentration of calcium

$\boldsymbol{r}_2$ = band 2
$\boldsymbol{r}_1$ = band 1

$$Mg = 0.323 - 0.356\boldsymbol{r}_4 + 2.149\boldsymbol{r}_1 + 0.978\boldsymbol{r}_2 \qquad (4)$$

where, mg = % concentration magnesium

$\boldsymbol{r}_2$ = band 2
$\boldsymbol{r}_1$ = band 1
$\boldsymbol{r}_4$ = band 4

Further data analysis is needed to determine how well the model can predict the nutrients level. Regression models that have been produced were used to estimate the nutrient concentration in the study area.

Results of this analysis shows that nutrient concentration at the micro-level can be successfully detected using remote sensing technique. Further analysis using information from Landsat-5 TM satellite data shows that remote sensing can also be applied to detect and mapped the nutrient concentration at Macro level. For this purpose, Landsat-5 TM images have been processed and image maps showing the distribution of nutrient concentration in the study area have been produced. Table 1 shows the % amount of nutrient concentration obtained from foliar analysis and Table 2 shows the percentage estimated amount of nutrient concentration in each plot of the study area.

Table 1. The amount of nutrient concentration obtained from foliar analysis.

Plot	N(%)	P(%)	Ca(%)	Mg(%)
Plot01	2.79	0.151	0.55	0.32
Plot02	2.80	0.155	0.73	0.31
Plot03	2.79	0.158	0.58	0.25
Plot04	2.76	0.150	0.59	0.31
Plot05	2.89	0.162	0.69	0.31
Plot06	2.77	0.164	0.64	0.28
Plot07	2.97	0.155	0.73	0.25
Plot08	2.91	0.142	0.72	0.29
Plot09	2.82	0.133	0.69	0.30
Plot10	2.86	0.140	0.75	0.36
Plot11	2.68	0.151	0.64	0.36
Plot12	2.71	0.132	0.65	0.33
Plot13	2.85	0.161	0.67	0.33
Plot14	2.72	0.151	0.65	0.34
Plot15	2.84	0.139	0.76	0.33
Plot16	2.77	0.115	0.62	0.30

Table 2. The amount of nutrient concentration estimated using model.

Plot	N (%)	P(%)	Ca(%)	Mg(%)
Plot01	2.89	0.162	0.70	0.26
Plot02	2.88	0.162	0.71	0.25
Plot03	2.86	0.163	0.67	0.31
Plot04	2.83	0.163	0.69	0.27
Plot05	2.81	0.161	0.70	0.25
Plot06	2.85	0.161	0.70	0.26
Plot07	2.82	0.161	0.70	0.25
Plot08	2.78	0.159	0.70	0.23
Plot09	2.82	0.161	0.69	0.26
Plot10	2.80	0.161	0.71	0.24
Plot11	2.81	0.161	0.71	0.24
Plot12	2.84	0.161	0.70	0.26
Plot13	2.82	0.160	0.70	0.25
Plot14	2.86	0.162	0.70	0.27
Plot15	2.84	0.162	0.69	0.27
Plot16	2.81	0.160	0.70	0.24
	RMSE	***RMSE***	***RMSE***	***RMSE***
	0.120	**0.019**	**0.073**	**0.070**

4.Conclusion

The ability of remotely sensed data to quantitatively detect and estimate the nutrient concentration in the soil would helped to improved yield forecasts and also would provide useful information for farm managers in making day-to-day management decision. Moved to change from the traditional time consuming and costly method of soil analysis to this new technique of data analysis have to be made to ensure better and efficient farm management.

Compared to foliar analysis conducted in oil palm plantation which came from samples of blocks in which each block are made of substantial acreage, approximately about 10 – 25 ha, mapping of nutrient with remote sensing technique generated in this study is far better in recording and exhibiting the spatial variability of nutrient concentration.

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