

Detecting nutrients deficiencies of oil palm trees using remotely sensed data

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Abstract. Oil palm plantation management involve crucial role for the farmers. The remote sensing imagery has widely used nowadays in order to monitor oil palm tree in plantation. To pact with the problem, the use of vegetation indices analysis on satellite image on plantation will examine the ability of spectral data in determining the greenness of the trees. Vegetation Indices are used for estimating the crops and vegetation variables by using visible and near-infrared region (NIR) from the electromagnetic spectrum. The healthy tree will display very low reflectance and transmitted in visible region and very high reflectance transmitted in NIR. The chlorophyll absorption in reflectance and normalizes pigment chlorophyll vegetation indexes will show a loss of chlorophyll pigment compared to healthy oil palm trees. Besides, pH. value and soil nutrient will be examined to determine their effect towards the trees. In addition, the laboratory test sample is done to analyse the pH. value and major nutrient status of nitrogen (N), phosphorus (P) and potassium (K) together with their relationship with the remotely sensed data.

1. Introduction

Oil palm has been planted in large scale of area and it requires on time monitoring. In order to overcome the problem, satellite imagery has being used to identify the unhealthy tree at the plantation. The result of this project will reduce the time constraint for monitoring and help to control the plantation. It is important for planning to build an integrated information system in order to access accurate and up-to-date data which is used in the activities of research including planning, management, controlling and also in overcoming unpredictable situation. This study will help the farmers in decision making. Besides, the large area of oil palm plantation considers many criteria and implementation in order to get the large productivity of crops or fruit bunches. As to maximize the efficiency of management in oil palm plantation, geospatial analysis is implemented. This is because, the useful information from the remote sensing data can be integrated in plantation especially in oil palm. Farm manager can obtain details and specific crops together with soils over the large area to assist decision making. If the plantation is managed in accordance with the right decision and rule by the farmer, it will affect the productivity improvement of oil palm fruits bunches. The criteria that must be considered are including the land selection, planting material, technical management, harvesting and environment. If all the criteria in the oil pam plantation can be managed and integrated with each other, production of fruits can be obtained. Therefore, the next precaution and caution can be taken in order to get the huge profit in plantation production. Thus, the result of analysis can be used to maintain the sustainable analysis.



2. Study area

This study was carried out at Felcra Kampung Kurnia Gelong Gajah. It is situated in Ayer Tawar, Perak, Malaysia. There are three phases of the oil palm plantation in Felcra Kampung Kurnia but the study area for this project is on the Phase 3 and its geographical coordinates are 4° 23' 00' North, 100° 47' 29" East. The area of oil palm plantation is about 100 acre and it is been planted since year 2001. The oil palm plantation had been conducted and supervised by Felcra Berhad Perak.

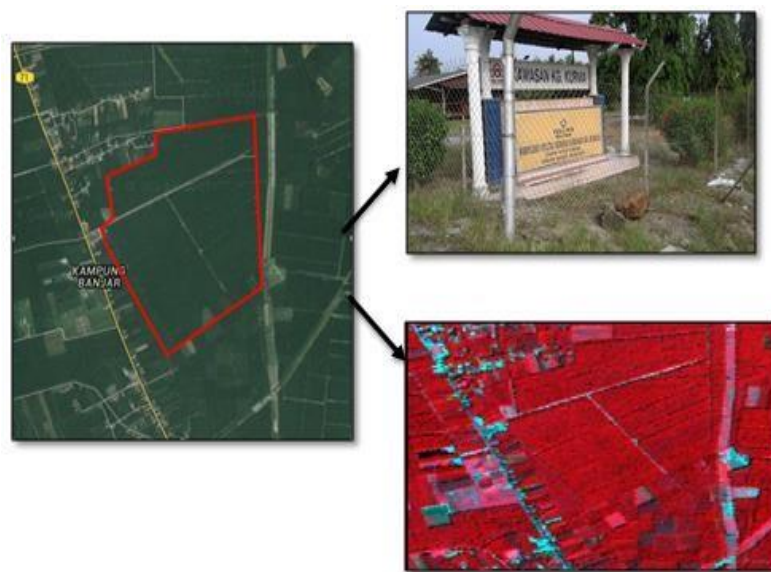


Figure 1. Study area (Ayer Tawar, Perak).

3. Methodology

There are two method that are being used for this project. The methods are image processing on remote sensing and soil test for palm trees ground data. The following steps are conducted in order to identify the condition of unhealthy and healthy oil.

3.1 Soil sampling

Nutrient content (N.P.K) and pH value are examined from five sample of soils at the plantation area. The soil test is conducting in the laboratory. It is being done for the purpose of estimating and analysing the plant-available such as method and chemical solution that are used, tested or verified for the correlation of exact nutrient. Then, the regression equation is constructing to get the nutrient content (N.P.K) on soil tested. Apart from that, the soil pH estimation is important to know either the oil palm trees growth suitability for neutral, acidic or alkaline.

3.2 Image processing

Image processing is the important step in the remote sensing technique. The processing of SPOT-5 image is done through certain tools in the ERDAS imagine 2014 software. The tool includes reprojection, subset, and vegetation index of NDVI and SAVI. The processing is done for determination of accessing, interpreting and analysing the result.

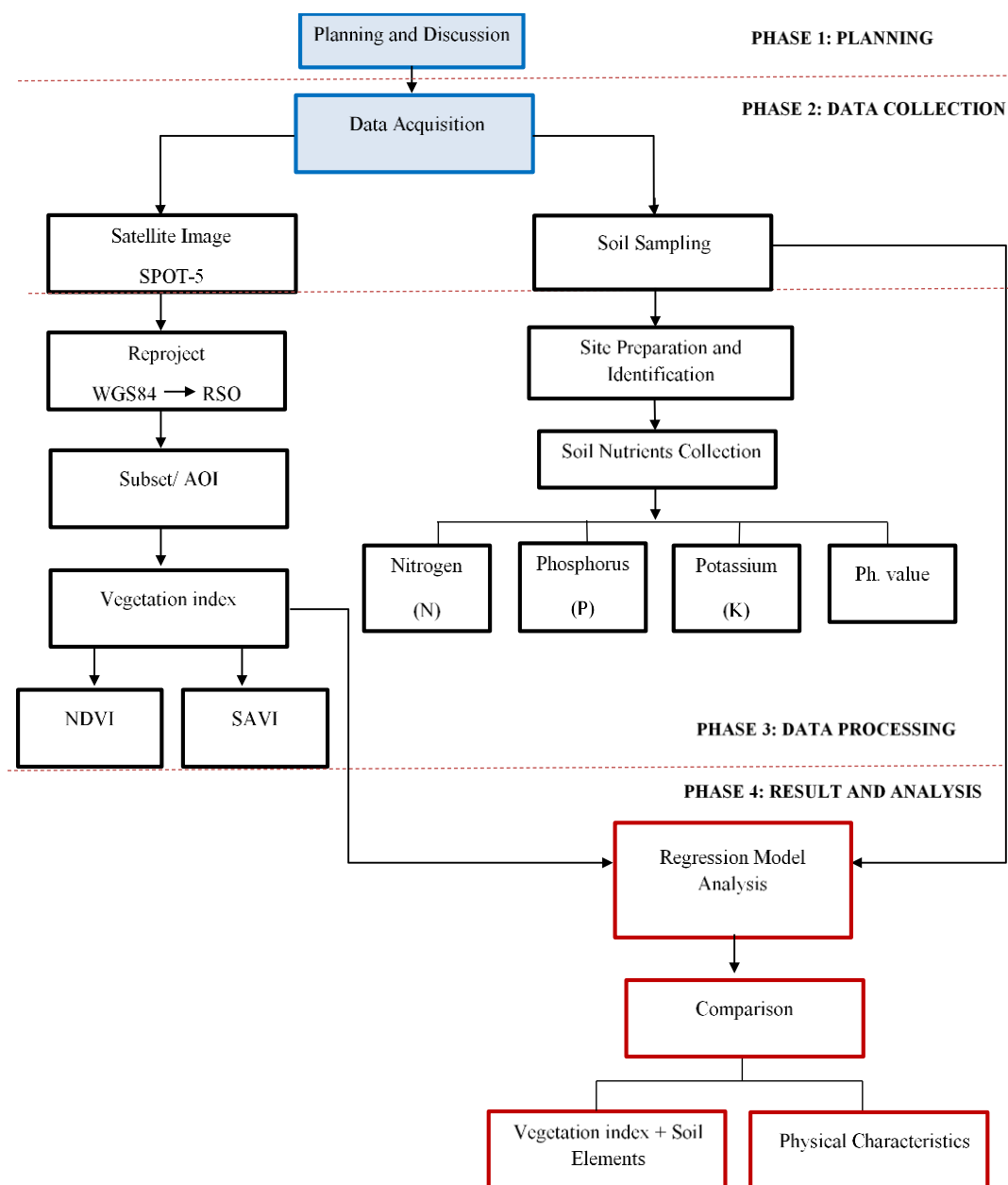


Figure 2. Flowchart of methodology.

4. Results and discussion

The result and analysis of the project study is based on the image processing using ERDAS Imagine software, soil analysis of nutrient contents including nitrogen, phosphorus, potassium and pH value. Apart from that, the relationship of NDVI and SAVI are described by regression model towards the soil analysis.

4.1 Analysis on plot area

There are five plot area in this study area. Before the soil sampling was collected, the observation is made on the physical botanical on the oil palm trees on the plantation. The healthy and unhealthy plot area was selected for identifying the nutrients content. The result of the plot sample is stated on table below.

Table 1. Identification on the plot area.

Plot sample	Coordinate location of plot area (m)		Area (m ²)	Physical condition of the plot area
	x	y		
1	311554.58	485331.00	261605.45	Healthy
2	312203.02	485689.58	461572.07	Healthy
3	311884.60	484837.14	385592.61	Unhealthy
4	312531.23	485258.92	160433.07	Unhealthy
5	311796.43	485933.77	600754.37	Healthy

4.2 Analysis on nutrients content

The soil nutrient testing has be done for five composite sample on the site location. There are ten soil samples for each plot are collected and mixed into single sample. The soil sample have been labelled and analyzed in the soil laboratory.

Table 2. Result of soil sampling.

Plot	Element						pH. Value
	Total Nitrogen (N) %	Status	Phosphorus (P) mg/kg	Status	Potassium (K) meq/100g	Status	
1	0.25	Very High	197	High	0.75	Very High	5.8
2	0.20	Very High	40	Very Low	0.98	Very High	5.4
3	0.17	Moderate	7	Very Low	0.20	Low	5.0
4	0.14	Moderate	81	Very Low	0.19	Low	4.8
5	0.21	Very High	180	Low	0.65	Very High	5.0

Based on the five samples analyses of soil stated on Table 2, the highest percentage of total nitrogen in soil for sample on the Plot 1, which is 0.25 %, while the lowest is in sample on the Plot 4, which is 0.14%. By referring to Goh, K.J. [3] on the soil nutrient, it is suggested that the oil palm plantation specifically above nine years by the optimum composition of nitrogen needed in soil for oil palm tree should less or same 0.12 %. Thus, any percentages that below than that level is consider as low and the value that higher than the level is consider as high. In this case, the Plot 4 has the lowest nitrogen content which is 0.14% and Plot 1 has the very high of nitrogen content which is 0.25%. The value of nitrogen is optimum. E.G.Ilori, P.N.Okonjo, [2] said that all plant need nitrogen for growth and almost all the nitrogen in the soil is in an organic form. By referring to the five samples analyses of soil, the highest content of available phosphorus is on Plot 1, which is 197 mg/ kg followed by Plot 5 is 187 mg/kg. By referring to Goh, K.J. [3], the available phosphorus in soil for oil palm tree should above 60mg/kg. The value that indicate above than 60 mg/kg is consider as high. Any value that below than 25 mg/kg is consider as low. Based on this study, the lowest of available phosphorus content is on Plot 3, which is 7 mg/kg. Plot 3 has a lot of different of soil analyzed, compared to other plots. The low content of phosphorus may be caused by many factors. Ian Rankine and T.H. Fairhurst [4] said that phosphorus deficient in plants may be underdeveloped with short fronds, and the palm trunk may have a noticeable pyramid shape. Based on the five sample analyses of soil, the highest content of potassium is on Plot 1, which is 0.98 meq/100g and followed by Plot 1 which is 0.75 meq/100g. Meanwhile, the lowest of phosphorus content is on Plot 4, which is 0.19 meq/100g. Both soil potassium status in Plot 3 and 4 has slightly difference by 0.1 meq/100g. As referred to Goh, K.J. [3], the study of the soil that indicated as has high potassium content is above 0.30 cmol/ kg and the value below than 0.20 cmol/ kg is point to as low of potassium content. Therefore, any value that above than 0.30 cmol/ kg is consider as high and contrary. The nutrient of potassium can affects fruit bunch size, fruit bunch, and also prevention of disease disruption. Furthermore, the potassium deficiency is usually on peat and sandy soils. Besides, the low acid in soil also cause potassium deficiencies.

4.3 Analysis on soil properties

The soil properties that has been analyse is pH value of the soil. The pH. value indicate the acidic or alkali status of the soil sample. The chart below show the pH value varies on the five plot. Soil pH plays a great role because a lot of change either on biological nor chemically activities in the soil. E.G.Ilori, P.N.Okonjo [2] said that the pH will affect the availability intake of other nutrients. Based on the result from the five plot of soil analyses, the Plot 3 and 4 has the lowest of pH value and its equivalent to nutrients of nitrogen, phosphorus and potassium (N.P.K) that available in soil. All the pH value of soil sample has range between 5.8 to 4.8 and the mean of the entire area is about 5.2 and had proven that the soil is slightly acid. In addition, Plot 3 and Plot 5 has the same pH value, which is 5.0. By referring to the study in Pathumthani province in Thailand by Ukrit Sahapatsombut [9] and Nigerian Institute for Oil Palm Research in Benin City, Nigeria, both study have proven that the suitable pH value for oil palm plantation is ranges from 4 to 6. It can be planted in acid soil. Based on the study of soil fertility on oil palm by Dr. E Mutert [6], in Southeast Asia, the oil palm are grown on acid soil. In the meantime, the range of pH value in soil in the study area is 5.2 and indicated that the pH of the soil on the study area is acidic.

4.4 Analysis on nutrients content

The vegetation index is for detecting the greenness of the tree. Image SPOT-5 is used during this project. It is because the resolution of SPOT-5 is higher than the Landsat imagery. In addition, SPOT-5 has two spectral band that is important in NDVI analysis which are Band 3 and Band 4. Band 3 is red and band 4 is near infrared (NIR). Generally, the healthy vegetation will absorb most of the visible light that falls on it and reflect a large portion of the near infrared. Sim Wright [7] said that the unhealthy vegetation reflect more visible light less near- infrared light. It can be concluded that the healthy oil palm has the high of NDVI value and the unhealthy oil palm tree has the lowest NDVI value. NDVI is calculate from the formula that is stated below:

$$NDVI = (NIR - RED) / (NIR + RED) \quad (1)$$

The RED stand for spectral measurement of Band 3 and NIR is spectral measurement in band 4. The NDVI value varies from range -1.0 to +1.0. Desmond Ofofu Anim, Amos Tierayangn Kabo-bah, Philip Nti Nkrumah, Raphinos Tackmore Murava [1] said that the positive value show different type of vegetation classes, where near zero and negative value show non vegetation classes such water, snow, built-up area and barren area. Based on this project, the lowest of NDVI value is 0.30 as there is only oil palm plantation spot. The non-vegetation is distinguished by subset the plot area.

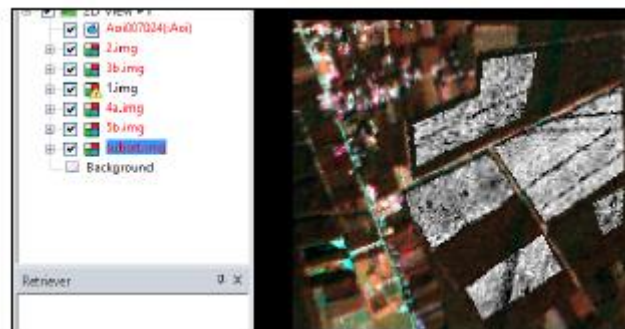


Figure 3. NDVI process on the plot area.

Table 3. The result of NDVI.

NDVI	Min	Max	Median	Mean
Plot 1	0.5000	0.67816	0.65032	0.649
Plot 2	0.45833	0.68000	0.64796	0.645
Plot 3	0.21818	0.34375	0.31285	0.312
Plot 4	0.28000	0.0.3813	0.30707	0.306
Plot 5	0.56204	0.67251	0.30705	0.645

The NDVI of vegetation indices is process through ERDAS Imagine 2014 software. By using the reflectance of spectral, the green vegetation of the oil palm can be detected. Table 3, shows the NDVI value of the five plots. The value of NDVI range from 0.30 to 0.65. These variety of analysis show the classification of the unhealthy and healthy oil palm tree on the plantation. The healthy tree has low red light reflectance and high near infrared reflectance. Therefore, the value of NDVI is analysed as high. Based on the study of Veena Shashikant, Abdul Rashid Mohamed Shariff, Laili Nordin and Biswajeet Pradhan [10], the unhealthy tree has high red light reflectance and lower near infrared reflectance so the result of the NDVI value is low. It also indicated that the lowest of NDVI value are on the Plot 3 and Plot 4. It was predictable because of the observation on the physical of the trees for ground data collection contain most of the oil palm trees that nearly dead and damages.

4.5 Result of SAVI

SAVI analysis (Equation 2) was developed to minimize soil influences on canopy spectral by incorporation a soil adjustment factor L into the dominator of normalized differences vegetation index (NDVI) of (Equation 1). For optimal adjustment of the soil effect, L factor should inversely with the amount of vegetation present.) SAVI equation created by Ji.Qi, A.Chehbouni, A.R.huete, [5] is shown as below:

$$SAVI = \frac{NIR - RED}{NIR + RED + L \times (1 + L)} \quad (2)$$



Figure 4. Result of SAVI analysis on the plot area.

Table 4. The result of SAVI.

SAVI	Min	Max	Median	Mean
Plot 1	0.89701	1.0143	0.97262	0.972
Plot 2	0.68512	1.0171	0.96911	0.964
Plot 3	0.90492	1.0148	0.97491	0.975
Plot 4	0.87197	1.0029	0.95843	0.958
Plot 5	0.8400	1.0058	0.96826	0.965

The value of NDVI range from 0.30 to 0.65. These variety of analysis show the classification of the unhealthy and healthy oil palm tree on the plantation. As Veena Shashikant, Abdul Rashid Mohamed Shariff, Laili Nordin, Biswajeet Pradhan [10] have mentioned that the healthy tree has low red light reflectance and high near infrared reflectance. Thus, the value of NDVI is analysed as high. It also indicated that the lowest of NDVI value are on the Plot 3 and Plot 4. The average of the SAVI value is 0.966 and it show that the value is not much differences. Based on the SAVI analysis the result do not as same as the soil analysis. Based on the SAVI analysis, the result do not as predicted towards the soil analysis.

4.6 Comparison of NDVI and SAVI analysis

The relationship of both data from soil test analysis and vegetation indices is done by regression model. The purpose of the regression model analysis is to predict the value of the dependent variable for individual and estimating the effect of some explanatory variable on the dependent. The regression algorithm is examined to get the R^2 . The R^2 shows the correlation of NDVI, SAVI and the nutrients analysis. The relationship can be seen on the simple linear of the regression model analysis.

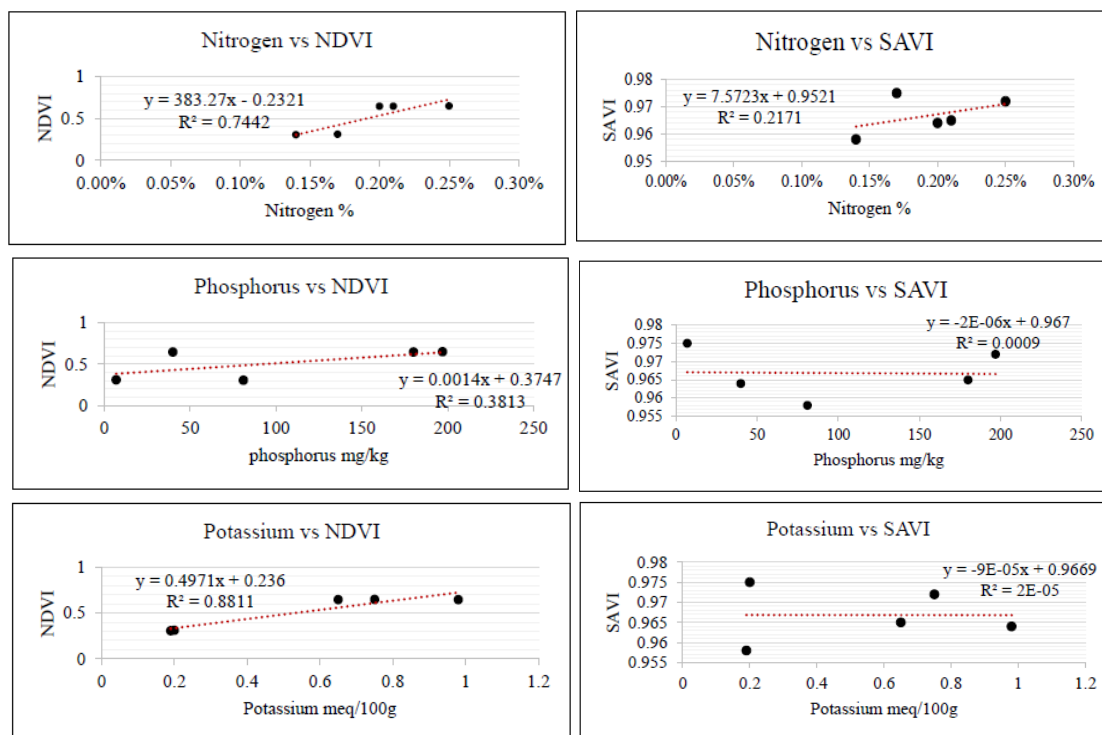


Figure 5. The correlation relationship of NDVI and SAVI towards nutrients analysis.

4.7 Comparison on the vegetation indices and soil analysis

After done the correlation analysis of both technique of NDVI and SAVI towards the soil properties, the vegetation indices show the positive and negative correlation can be compared in order to evaluate which of the vegetation indices has the strong correlation relationship. The R^2 value are listed and compared according to the nutrients element.

Table 5. Comparison of both correlation relationship of vegetation indices towards soil properties.

Correlations element	R^2 value	
	NDVI	SAVI
Nitrogen (N)	0.7442	0.2171
Phosphorus (P)	0.3813	0.0009
Potassium (K)	0.8811	0.012
pH. value	0.4789	0.1969

By referring to Table 5, the correlation of NDVI show positive relationship compared to the SAVI. On the NDVI, the value indicate exact as the physical condition on the plot area. The correlation of SAVI towards the soil properties indicate negative correlation relationship whereby the element range from 0.100 to 0.2171. Moreover the correlation of R^2 on Potassium element cannot be identified. Therefore, the Normalized Differences Vegetation Indices (NDVI) has a strong correlation compared to Soil Adjusted Vegetation Indices (SAVI) towards element in soil nutrients.

4.8 Comparison on the physical characteristics

After done the soil analysis and vegetation indices on the plot area, the physical characteristics of the oil palm tree towards the nutrient deficiencies that related is identified. There are many physical characteristics of oil palm tree that can be diagnosed nutrient deficient such as trunk, leaf, fruits and frond, but the easiest to spot is on its leaves. Beside soil analysis, Timothy, K. Broschat [8] said that the leaves of the oil palm tree also can resemble the soil profile. Nitrogen (N) is the most important element in plant including oil palm. Based on the oil palm tree in the Plot 3, the leave indicated lacking on the nitrogen composite. It is because the leaves and petiole of the oil palm tree show yellowish colour and the frond is widely open. Based on the research study in Florida by Timothy, K. Broschat [8] regarding the nutrient deficiencies on palm tree, the nitrogen deficiencies started on the oldest leaves turn into light green then slowly spread to young leaves and in a time will becoming discoloured. In addition, golden-yellow brown petiole, rachis and crown shaft colour on the oil palm tree is cause by nitrogen deficiencies. The nitrogen deficiencies is cause by insufficiencies N in the soil. The lack of nitrogen deficiencies on the Plot 3 is proven, whereby the nitrogen in soil is lowest than other plots. In long period, the sizes of leaves will becoming much smaller and trunks tapering to a point as a result.



Figure 6. Oil palm tree spot on the plot 3 area.

There are no specified study that relate to the phosphorus (P) deficiencies as the positively react to the nitrogen and potassium. Based on the study in TNAU Agritech Horticulture, the symptom on the lack of phosphorus is high frequency of premature dryness of older leaves occurs and the oil palm tree that has enough phosphorus will increase the fruit productivity and number of female inflorescences. On the Plot 4, there are few of oil palm tree that shown low quality of fruit bunch production and the leaves indicate dryness as show in brown colour on the most frond. Referred to the soil analysis, the Plot 3 has the lowest phosphorus element and it can be conclude that the oil palm tree on the area is lacking on phosphorus content.



Figure 7. Leaves dryness indicate in brown colour. Fruit bunches is unusually small.

Potassium (K) deficiencies is usually nutritional symptom in palm and always show on the oldest leaves. The symptom show on the older leaves mottled with yellowish spot that are translucent when viewed. Apart from that, Timothy, K. Broschat [8] also said that the early symptoms appear as translucent yellow or orange spotting on the leaves and may be accompanied by necrotic spotting as well. Those symptoms are obviously shown on the area of Plot 3 and 4.



Figure 8. Symptom in lacking potassium on leaves.

5. Conclusion

According to the analysis of correlation relation acquired, both technique of soil sampling and NDVI are correlated to each other in finding the nutrient deficiencies of oil palm tree and this method can give a good identification of vegetation area. The regression model shown the correlation relationship for each nutrient elements with the vegetation indices. Based on the comparison of the analysis on soil data, it shows that the Vegetation Indices of NDVI gives better information compared to SAVI in order to find the nutrients deficiencies. Others than that, for the pH value, does not have strong correlation compared to the nutrients content towards the vegetation indices.

6. Acknowledgement

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7. References

- [1] Desmond Ofosu Anim, Amos Tiereyangn Kabo-bah, Philip Nti Nkrumah, Raphinos Tackmore Murava . (2013). Evaluation of NDVI Using SPOT-5 Satellite Data for Northern Ghana. *Environmental Management and Sustainable Development*, 167-182.
- [2] E.G. Ilori, P.N. Okonjo. (2014). Assessment of Soil Nutrient status of a Oil Palm Plantation. *Agriculture Journal*, 127-131. Food and Agriculture Organization of the United Nations.
- [3] Goh, K.J. (2004). Fertilizer Recommendation Systems for Oil Palm Estimating the Fertilizer Rates. 1-37. Haifa Chemicals Ltd. (2014). How to avoid common nutrient deficiencies in oil palm.
- [4] Ian Rankine and T.H. Fairhurst. (1999). Management of Phosphorus, Potassium and Magnesium. *Better Crop International*, 1-15.
- [5] Ji.Qi, A. Chehbouni, A.R. Huete. (1994). A Modified Soil Adjusted Vegetation Indices. *Remote Sensing Environment*, 112-126.
- [6] Mutert, D. E. (1999). Suitability of Soils for Oil Palm in Southeast Asia. *Better Crops International*, Vol. 13, No. 1.
- [7] Sim Wright. (1999). Retrieved from Normalized Difference Vegetation Index analysis on forestry and crop management. Timothy, K. Broschat. (2005). Nutrient Deficiencies of Landscape and Field-Grown Palms in Florida. *Environmental Horticulture Department University of Florida*, 1-10.
- [8] Timothy, K. Broschat. (2005). Nutrient Deficiencies of Landscape and Field-Grown Palms in Florida. *Environmental Horticulture Department University of Florida*, 1-10.
- [9] Ukrit Sahapatsombut, Rapeepun Rahong and Samai Jai-in. (n.d.). Oil Palm Plantation in Acid Soil at Rangsit field. Thailand.
- [10] Veena Shashikant, Abdul Rashid Mohamed Shariff, Laili Nordin, Biswajeet Pradhan. (2012). NDVI of oil palm trees by LANDSAT-5 Imagery. *The 3rd Asian Conference on Remote Sensing*, (pp. 1-4). Selangor.