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Determination of rubber-tree clones leaf diseases spectral using Unmanned Aerial Vehicle compact sensor

Hamzah Mohd Ali[1], Abd Wahid Rasib[1],Nurmi Rohayu Abd Hamid[2], Zarawi Abd Ghani[2], Ikhsan Mahsuri[2], Abdul Razak Mohd Yusoff[1], Osman Zainon[1], Khairulnizam M Idris[1] and Rozilawati Dollah[3]

[1]TopicalMap Research Group, Department of Geoinformation, Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia, 81310 Skudai, Johor. Malaysia
[2]Malaysian Rubber Board, RRIM Research Station Sg Buloh, 47000, Sg. Buloh, Selangor, Malaysia
[3]Faculty of Computing, Universiti Teknologi Malaysia, 81310 Johor, Malaysia

abdwahid@utm.my

Abstract. Currently, one of the remote sensing platform that adequatly been used is Unmanned Aerial Vehicle (UAV) which suitable in monitoring and mapping for agriculture sector at large area payload by compact sensor. Thus, this study is deploy the UAV compact sensor to identify the characteristics of rubber tree clone leaf diseases based on two groups of spectral wavelength which is visible (RGB: 0.4 µm – 0.7 µm) and near infrared (NIR: 0.7µm – 2.0 µm), respectively. Spectral obtained using UAV platform is then to be validated with ground observation handheld spectroradiometer. Eight types of rubber tree clones leaf at three different conditions (healty, unhealty and severe) were randomly selected within the 9.4 hectare Experimental Rubber Plot, Rubber Research Institute of Malaysia (RRIM), Kota Tinggi, Johor whereby consist RRIM 2000 series, RRIM 3000 series and PB series, respectively. As a result, this study has found that the spectral trend based on UAV compact sensor from eight different types of rubber tree clones leaf shows the similarity to the general basic vegetation spectral in transition from blue to NIR spectral. However, referring to spectral obtained from handheld spectroradiometer there is no drastically changes of spectral in visible region but drastically increase in NIR region. Thus, this study has conclude that the spectral signature characteristics for healthy, unhealthy and severe for leaf diseases from every single rubber tree clones can be identified obviously in NIR region using UAV compact sensor.

1. Introduction

Nowadays, agriculture sector has become one of the contibutors towards enhancing national economic development. The agriculture sector consists of forestry, oil palm, logging, rubber, fisheries, livestock and another agriculture crop such as fruit, paddy, flowers and tea. The demands for agriculture products has increase proportionally with world population. Hence, provide a great opportunity to increase the national income. As one of the important commodity crops in Malaysia, rubber is commercialising for latex timber and Natural Rubber (NR) production. According to Food and Agriculture Organization (FAO), rubber plantations cover large areas in tropical regions and are projected to expand further [1],[2] In fact, Malaysia has become the world sixth largest producer of NR after Thailand, Indonesia, Vietnam and China. Malaysia has contributesd 5.5 % to total raw rubber supply and RM 20.18 billion to the national export (Department of Statistics Malaysia) [3] . Currently, the spread of diseases among rubber tree has influence to the decrement of latex, hence the study to determine the diseases that effect the rubber tree is essential. Thus, this study provide an insight for identifying rubber tree leaf diseases for eight different types of rubber clones which are PB 260, PB 350, RRIM 2001, RRIM2002 , RRIM 2007 , RRIM 2023 , RRIM 2024 and RRIM 3001 respectively using remote sensing spectral.

Rubber diseases can be categorized into four which are leaf disease, panel diseases, root disease, steam and branches diseases [4]. Furthermore, most of the diseases are causes by indigenous fungal parasites [5]. The common rubber leaf diseases that occurred in Malaysia is Oidium leaf diseases or also known as powdery mildew that causes by a fungus name Oidium heveae. The fungus mainly attack immature leaf during refoliation after wintering that causes growth retardation and reduction in latex yield and also defoliation and curling leaves [6]. The common method to control the outbreak of this disease is through chemical application but due to time consuming and labour intensive it be less effective. Currently, the application of remote sensing technologies for crop management has been widely used for monitoring growth and yield estimation. Remote sensing can detect the energy that was absorbed, reflected and transmitted from the plant through their spectral signature. Hence can identify the condition of the rubber leaf itself.

Lately, UAV platform widely used for precision agriculture [7], [8]. UAV able to provide real time data at large area coverage using shorter time. Several investigations [9] have demonstrated the advantages of UAV in comparison to satellite imagery and airborne regarding its low cost and greater flexibility in flight scheduling [10]. Hence, UAV is a proper tools for researcher and especially farmer to monitor their crops. Furthermore, the quantifying for entire plant population can be carried based on the crop sampling from the UAV spectral imagery. In addition, UAV can produce images without interfered by any cloud cover for orthophoto of spectral NIR and RGB whereby potential to cover the whole study area. The orthophoto of NIR spectral and RGB spectral can be used to produce vegetated spectral signature of the rubber leaf that range from 450 nm to 900 nm. The spectral response graph trend will be interpreted and compared it with grooved sampling spectroradiometer graph for the tree growth analysis. Based on the spectral signature range wavelength of 450 nm to 900 nm, the condition of the tree leaf can be identified according to the tree clone whether it healthy, unhealthy and severe respectively, which different condition of rubber leaf will reflect and absorb differently at different wavelength.

2. Methodology

2.1. Study site

The study is conducted at Field 113, Pelepah Division, Research Station RRIM, Malaysian Rubber Board (MRB), the location is at 1° 47.778' N and 103° 51.343' E in Kota Tinggi, Johor as shown in Figure 1 .The total area of this field is 9.4 ha comprising 25 clones (RRIM 2000 series, RRIM 3000 series, PB series, and speculative clones). The soil type is Jeranggau series which is the Class 1 soil series and suitable for rubber plantation.

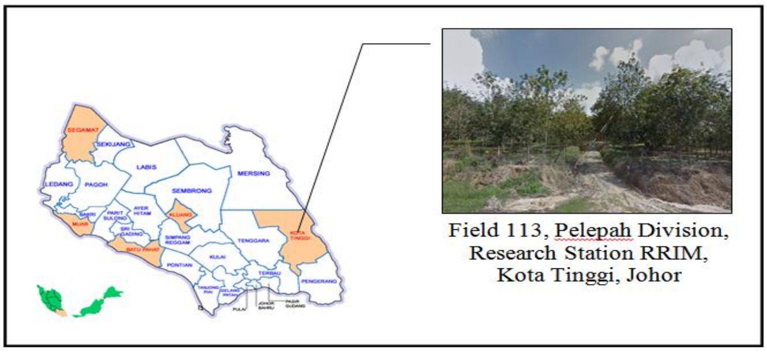


Figure 1. location of study area

In the study area, eight clones were selected based on MRB Planting Recommendation 2013 that are PB 260, PB 350, RRIM 2001, RRIM 2002, RRIM 2007, RRIM 2023, RRIM 2024 and RRIM 3001. Each clone was selected based on physical condition (healthy, unhealthy and severe infection of *Oidium* leaf disease) and was observed using UAV and spectroradiometer respectively as sampling location shown in Figure 2.

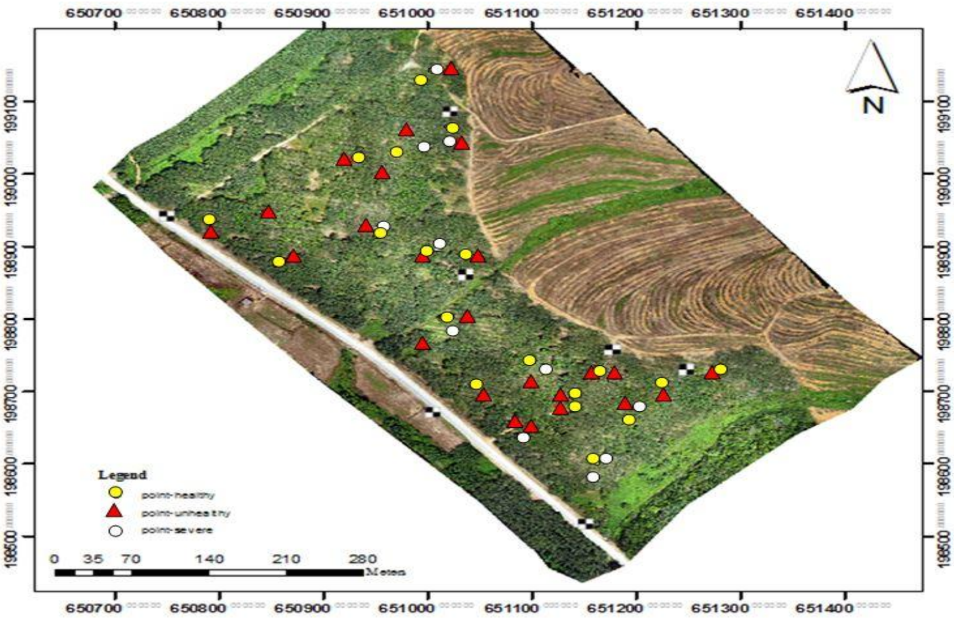


Figure 2. Location of selected samples (○ ▲ ● ,) and the location of Ground Control Points (▚) in Field 113, Pelepah Division, KotaTinggi

2.2. UAV and spectroradiometer data collection

In this study, there two types of data have been collected which are UAV spectral imagery and spectroradiometer observation data, respectively. Collection of aerial imagery was carried out in January 2016 by using low altitude Quadcopter Phantom 4, whereby equipped with two unit GPS ready MAPIR camera sensor. Two times of UAV manoeuvre have been set-up for two different type remote sensing sensor from Red, Green, Blue (RGB) and NIR. The similar configuration were used for each flying in order to revise the error that occurred between those two imagery that taken. For collection of spectral data, handheld spectroradiometer is used to observe the reflectance directly through different rubber leaf for every single clones with different leaf conditions. Ten leaf sample were randomly taken from different rubber tree. After identifying the diseases that occurred at the leaf, observation using the handheld spectroradiometer is conducted.

2.3. Flight planning

Designing flight planning is one of the important aspect for flying a UAV in order to obtained aerial imagery, without an accurate flight planning it is difficult to cover the whole study area. Flight planning consist of flight lines on the map of the specified area that shows the starting and end point of the flight and also contain control points for the photos [11]. During manoeuvre, the UAV need to be monitored through the controller in order to ensure the UAV in line with the flight planning. Thus, it will capture a reliable images.

2.4. Camera calibration

In this study, camera calibration is one of the important process for using UAV as a source for aerial imagery. Camera calibration is conducted in order to obtain the parameter of the camera calibration for interior orientation in image processing. The main purpose of camera calibration is to produce an accurate spatial information from the photo that produced.

2.5. Ground Control Point (GCP)

The ground control point (GCP) were established that served as a purposed for reference mark during image geocoded process and to produce sufficient points to do aerial triangulation, from the aerial triangulation the ground value for x, y and z can be obtain [11]. The main requiremennts for establishing good GCP is the selected location of GCP must be clearly visible in image and placed evenly around the study area to minimize the error that occured in scale and orientation. In this study, a total of seven GCP has been established as shown in Table 1 and distribution of GCP shows is Figure 2.

Table 1. The coordinates of the ground control point (GCP)

Ground Control Point	Latitude	Longitude
GCP 01	1.799033°N	103.853039°E
GCP 02	1.796252°N	103.855588°E
GCP 03	1.795276°N	103.856650°E
GCP 04	1.797430°N	103.856813°E
GCP 05	1.797211°N	103.857426°E
GCP 06	1.798457°N	103.855512°E
GCP 07	1.800450°N	103.855459°

2.6. Layer stacking

Images that obtained through UAV (RGB and NIR images) were processes by mosaicking to create orthophoto of the study area. Agisoft Photoscan were used for aerial image processing that invoved align photo, build dense cloud, build mesh and build texture, Figure 3 and Figure 4 illustrated the orthphoto of RGB and NIR images respectively. The combination orthophoto from RGB and NIR is known as layer stacking is done in order to produce a new images that consists of red, green, blue and NIR data.

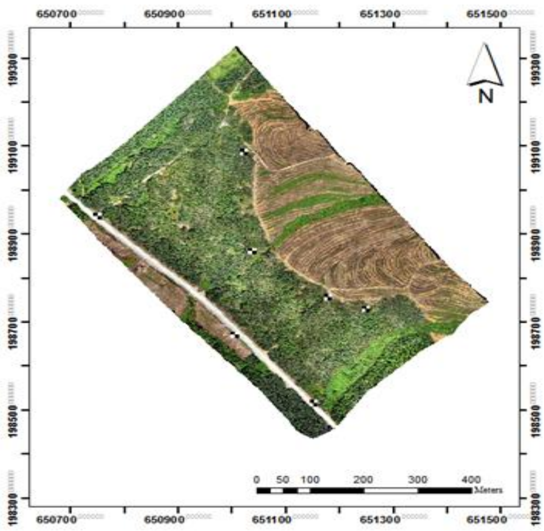


Figure 3. Generated orthophoto RGB images

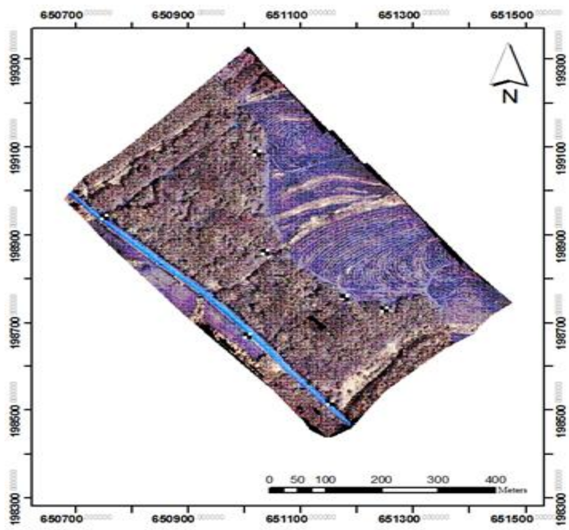


Figure 4. Generated orthophoto of NIR images

2.7. Processing

In this part, there two processing is done which is to produce spectral curve graph for spectroradiometer and UAV, also to produce Normalized Difference Vegetation Indexes (NDVI) map.

Based on the reflectance value, the NDVI map is generate. The NDVI is calculated from the red and NIR portion of the spectrum which gives the equation 1:

$$\mathrm{NDVI} = \frac{R_{NIR} - R_{Red}}{R_{NIR} - R_{Red}} \qquad (1)$$

where,

R_{NIR} = NIR radiation

R_{Red} = Visible red radiation

3. Results and Discussion

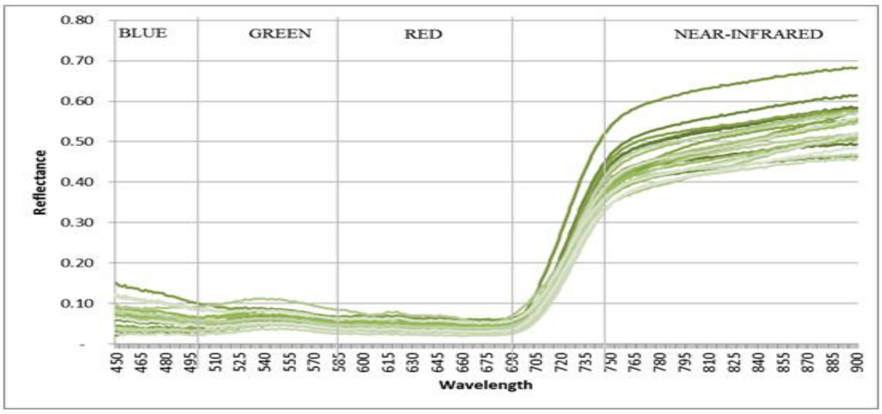
This study is conducted to identify the suitable spectrum region on spectral data that collected by using low altitude remote sensing technique which is UAV that will be used to identify or detecting the diseases that affected the rubber leaf. Hence, this section would emphasize spectrum region that suitable to detecting rubber leaf diseases and the NDVI image will produce to support the output of this study.

3.1. Spectral data analysis

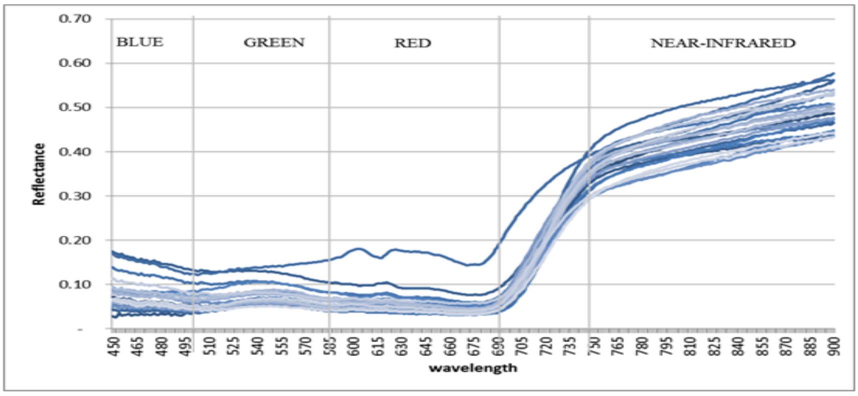
The affected rubber leaf with Oidium leaf disease can categorized into three based on the visual observation as shown in Figure 5, which are healthy (nil-low Oidium disease infection), unhealthy (moderate Oidium disease infection) and severe Oidium disease infection, whereas Figure 6 illustrate spectral reflectance for each category based on spectroradiometer observation from eight clones. Generally, the trend of spectral reflectance curve for healthy rubber leaf and severe Oidium leaf disease infection is similar with other vegetation [12]. Figure 7 shows the spectral curve from spectroradiometer and UAV images for healthy, unhealthy for every rubber tree clones.

(a) (b) (c)

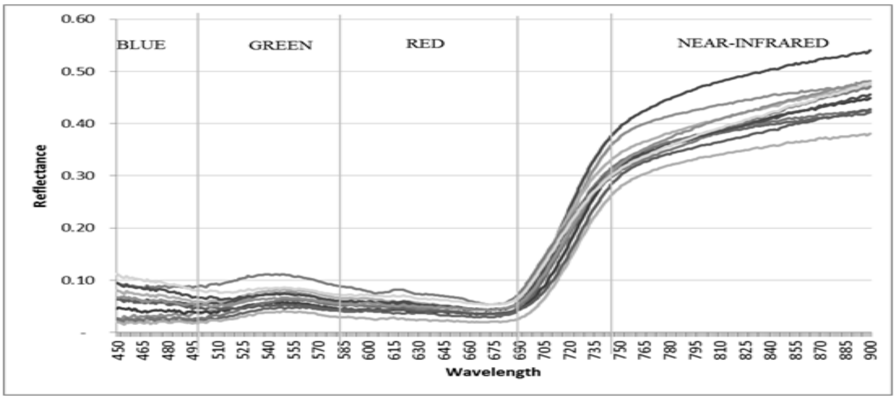
Figure 5. Physical reference of rubber leaf for (a) healthy leaf, (b) unhealthy leaf and (c) severe leaf



(a)

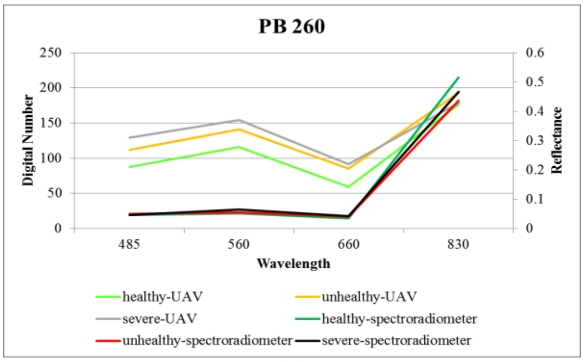


(b)

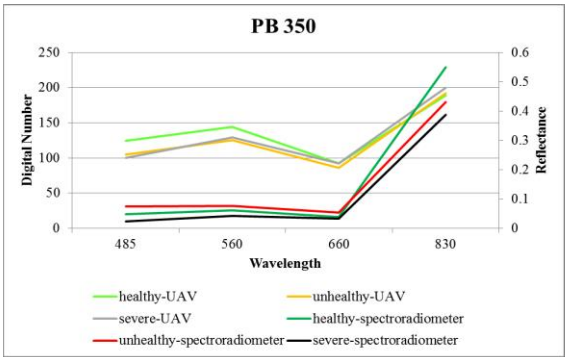


(c)

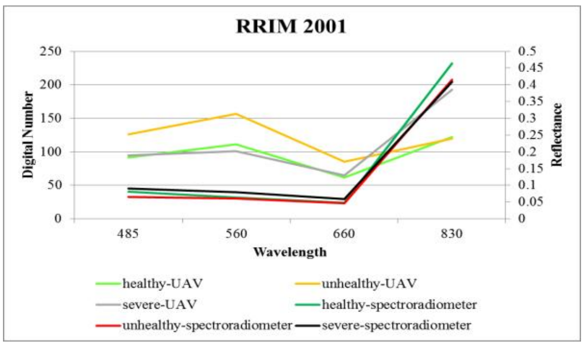
Figure 6. Spectral curve of rubber tree leaf using spectroradiometer (a) healthy; (b) unhealthy; (c) severe infection



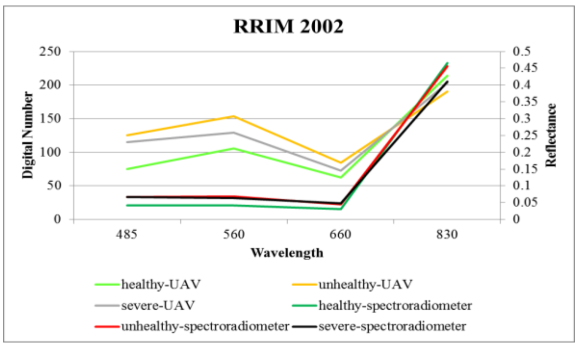
(a)



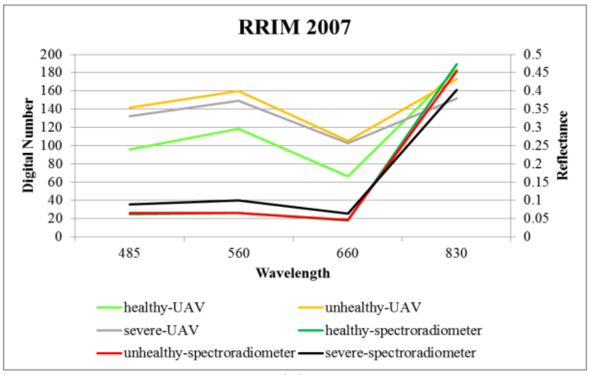
(b)



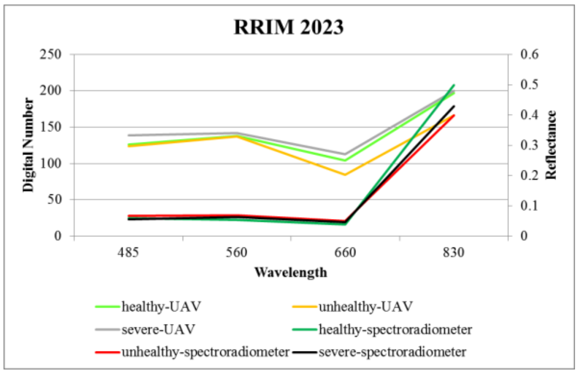
(c)



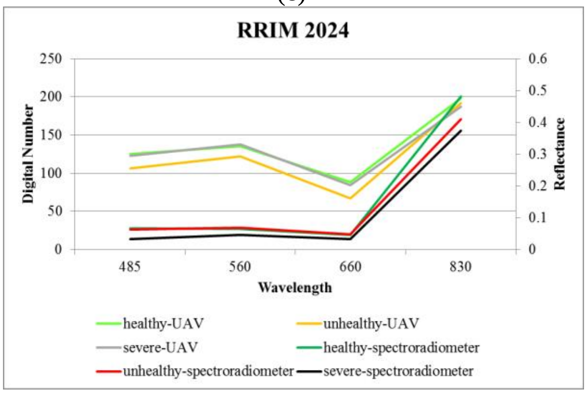
(d)



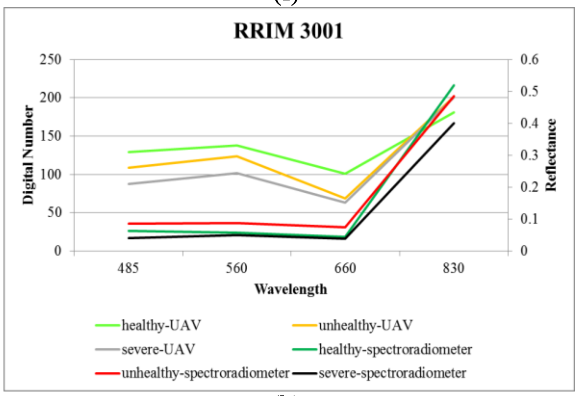
(e)



(f)



(g)



(h)

Figure 7. Spectral graph of spectroradiometer and UAV respectively for eight clones species of rubber tree leaf (a)PB 260; (b)PB 350; (c)RRIM 2001;(d)RRIM2002 ;(e)RRIM 2007; (f)RRIM 2023; (g)RRIM 2024 ;(h)RRIM 3001 at three different conditions (healthy, unhealthy and severe)

Eight type of rubber clones leaf are selected within the experimental plot for this study which are PB 260, PB 350, RRIM 2001, RRIM 2002, RRIM 2007, RRIM 2023, RRIM 2024 and RRIM 3001, the listed rubber clone can be distinguish through its leaf characteristic.Based on illustration in Figure 7, the trend for spectral value of UAV and spectroradiometer for each clones at three different condition is similar with each other which are increase during the transition between blue region to green region but decrease significantly when the transition from green to red region. However the value increase drastically when transition from red band to NIR occurred. In fact, the increasing value in NIR region for both data is due to the foliage decision that related to changes in leaf structure at the cellular level [13]. Theoretically, healthy leaf reflect better in green and NIR region, good photosynthesis plant will absorb most of the the visible light especially in red region by chlorophyll and reflect more in NIR region but for unhealthy and severe leaf it will reflect more in red region and less in NIR region.

3.2. NDVI map
Orthophoto that generated will be used to produce NDVI map as shown in Figure 8. Based on Figure 8, overall result shows that the rubber tree for eight different type clones that scattered at 9.4 ha experimental plot is not seriously affected by severe disease infection which can be validate by the greenness of rubber tree that indicates the healthiness of the tree. Furthermore, based on Table 2 the range of NDVI value for eight different type clones is greater than zero (> 80%) with maximum NDVI value 0.77 for healthy tree which signified that all rubber tree in 9.4 ha experimental plot are consistent healthy tree. For unhealthy and severe conditions has shown uncertainty with average value 0.20.

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Table 2. Extraction of NDVI value for eight clones respectively

NDVI			
Clones	Healthy	Unhealthy	Severe
PB 260	0.265 - 0.5680	0.280 - 0.338	-0.018 - 0.295
PB 350	0.1448 - 0.5983	0.006 - 0.460	0.315
RRIM 2001	0.1439 - 0.3333	-0.070 - 0.361	0.340
RRIM 2002	0.3373 - 0.7778	0.063 - 0.383	0.253
RRIM 2007	0.11257 - 0.5636	-0.011 - 0.231	0.011
RRIM 2023	0.1086 - 0.5575	-0.082 - 0.205	0.155
RRIM 2024	0.0368 - 0.4286	0.107 - 0.401	-0.003 - 0.390
RRIM 3001	0.0566 - 0.1678	0.181 - 0.336	0.378

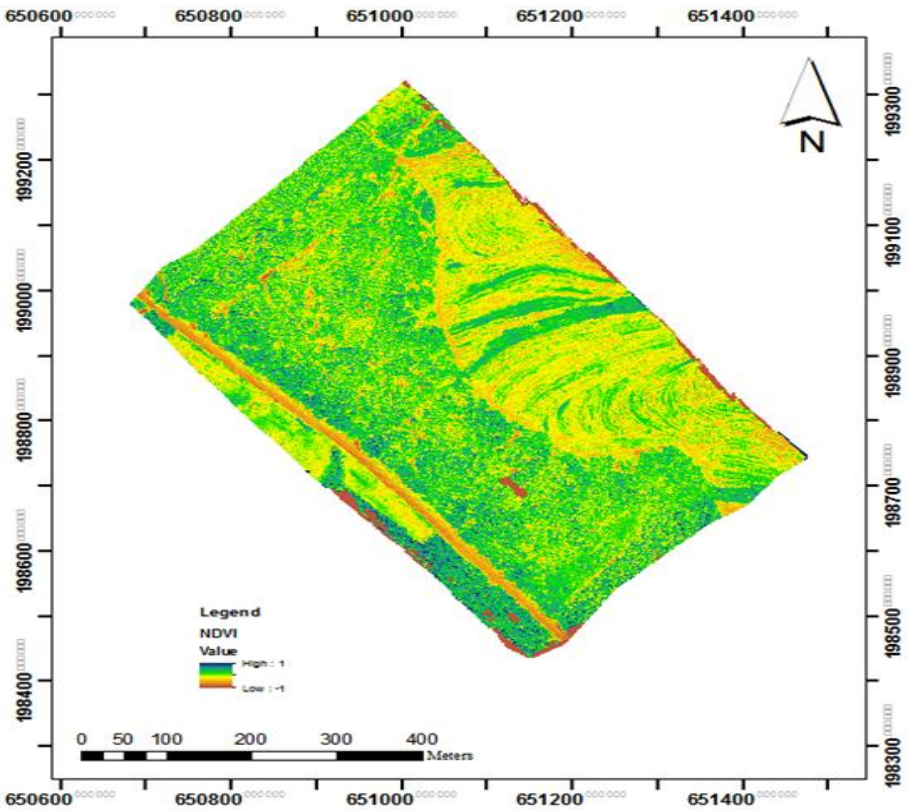

Figure 8. The NDVI map for rubber plantation area

4. Conclusion

As conclusion, this study manages to demonstrate the potential of low altitude remote sensing technology using UAV and non-matrix digital compact sensor for monitoring and detecting of Odium disease at different rubber tree clones. This study also can be used to provide an insight for the smallholder in the early stage in order to minimize the disease outbreak that occurred at the rubber tree plantation. Furthermore, the method that provided in this study is user-friendly and involving low-cost advanced technology. In addition, with the use of UAV it can provide real time data or information with less manpower needed at low cost budget. This study manages to found the similarity in trend by using UAV data and spectroradiometer data which can be used to detect healthy, unhealthy and severe Oidium disease infection on the rubber leaf.

At the end of this study, there are several things that can be improve in order to get a good result in the future. First, the spectroradiometer observation is required to be conducted in controlled area such as in the lab therefore the source of energy can be well managed. In addition, it also can reduce the errors by the differently exposed of the source of energy. Secondly, other physical parameter such as nutrition analysis of the rubber leaf and rubber clones should take into account as it also contributes to disease infection.

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References
[1] Fox J, Vogler J B, Sen O L, Giambelluca T W and Ziegler A D. 2012, simulating land cover change in montane mainland southeast asia. *Environ. Manag.***49** 968–79.
[2] Van der Laan C, Wicke B, Verweij P A and Faaij A P. 2016, Mitigation of unwanted direct and indirect land-use change-an integrated approach illustrated for palm oil, pulpwood, rubber and rice production in North and East Kalimantan, Indonesia. GCB Bioenergy **9** 429–44.
[3] Department of Statistics Malaysia, Natural Rubber Statistics 2015.
[4] Sripathi Rao B. 1975, *Maladies of Hevea in Malaysia* (Kuala Lumpur, Rubber Research Institute of Malaysia) 56.
[5] Sujaimi S. 2014, Early Detection of White-Root Disease for Rubber Tree Based on Leaf Discoloration with Neural Network Technique. *J. of Applied Science and Agriculture* **9** 341.
[6] Limkaisang S, Kom-un. S, Furtado E L, Liew K W, Salleh B, Sato Y and Takamatsu S 2005, Molecular phylogenetic and morphological analyses of oidium heveae, a powdery mildew of rubber tree *Mycoscience* **46** 220.
[7] Luo C, Li X and Dai Q. 2014, Biology's drones: New and improved *Science* **344** 1351.
[8] Marris E. 2013, Drones in science: Fly and bring me data *Nature* **498** 156–58.
[9] Zhang C and Kovacs J M. 2012, The application of small unmanned aerial systems for precision agriculture: a review. *Precis. Agric* **13** 693–712.
[10] Torres-Sánchez J, Peña JM, de Castro A I and López-Granados F. 2014, Multi-temporal mapping of The vegetation fraction in early-season wheat fields using images from UAV *Comput. Electron Agric.***103** 104–13.
[11] Colomina I M. 2014, Unmanned Aerial Systems for Photogrammetry and Remote Sensing: A Review ISPRS Journal of Photogrammetry and Remote Sensing. 79-97.
[12] Jensen J. 1996, *Introductory Digital Image Processing: A Remote Sensing Perspective, 2nd Edition* (New Jersey:Englewood Cliffd/ Prentice Hall) 181.
[13] Aldakheel Y Y and Danson F M, 1997. Spectral reflectance of dehydrating leaves measurement and modeling. *International Journal of Remote Sensing***18** 3683.