RUBBER DISEASE MAPPING USING LOW ALTITUDE MULTISPECTRAL IMAGES

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DEDICATION

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ABSTRACT

One of the most important rubber leaf diseases in Malaysia is *Oidium* leaf disease. A Severe outbreak of this disease may cause an annual yield loss with 20% decrement of latex production in a rubber plantation. Currently, data acquisition is obtained manually which results in lack effectiveness, costly, and typically labour incentive. However, recent technology using unmanned aerial vehicle (UAV) has potential to overcome these issues. The UAV is able to facilitate spatially and allow temporal flexible data acquisition using a compact camera payload. Therefore, this study intention is to identify the health of rubber tree that affected by *Oidium* leaf disease using low altitude remote sensing images that acquired from UAV platform. The study area is carried out at Experimental Rubber Plot, Research Station Malaysian Rubber Board, Kota Tinggi, Johor in order to generate the healthy, unhealthy and severe map. Those maps were produced using multiple regression analysis between spectral reflectance at blue (450 – 510 nm), green (530 – 590 nm), red (640 – 670 nm) and near-infrared (850 – 880 nm) based on UAV. *Oidium* leaf disease can be identified by low absorption of light at the red band and little at the near infrared band resulted of high reflectance at both bands. As a result, this study successfully to determine the condition of rubber tree caused by leaf disease using low-cost remote sensing technology which deploys the UAV and payload by the digital compact camera.

ABSTRAK

Salah satu penyakit daun getah yang terpenting di Malaysia ialah penyakit daun *Oidium*. Keparahan serangan penyakit ini boleh menyebabkan kehilangan hasil tahunan dengan pengurangan 20% produktiviti lateks di kawasan penanaman getah. Sehingga kini, cerapan data yang diperoleh secara manual menunjukkan kurang keberkesanan, mahal dan memerlukan tenaga kerja insentif. Namun, teknologi bagaru menggunakan kenderaan udara tanpa kawalan manusia (UAV) mempunyai potensi mengatasi isu-isu ini. UAV mampu memudahkan ruangan dan membolehkan cerapan data lebih mudah dengan penggunaan muatan kamera kompak. Sehubungan itu, kajian ini bertujuan untuk mengenalpasti kesihatan pokok getah yang terjejas disebabkan penyakit daun *Oidium* dengan menggunakan imej-imej penderiaan jauh pada ketinggian yang rendah yang diperoleh daripada platform UAV. Kajian ini dijalankan di Kawasan Penyelidikan Getah, Stesen Penyelisikan Lembaga Getah untuk menghasilkan peta sihat, tidak sihat dan parah. Peta-peta tersebut dihasilkan melalui analisa regresi diantara pantulan gelombang spektral pada biru (450 – 510nm), hijau (530 – 590 nm), merah (640 – 670 nm) dan inframerah dekat (850 – 880 nm) berdasarkan UAV. Penyakit daun *Oidium* dapat dikesan melalui serapan sedikit cahaya pada jalur merah dan jalur inframerah dekat memberi hasil pantulan yang tinggi pada kedua-dua jalur tersebut. Hasil kajian mendapati bahawa keadaan pokok getah yang dijangkiti penyakit dapat ditentukan menggunakan teknologi kos rendah penderiaan jauh UAV dengan muatan kamera kompak digital.

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CSWI	-	Crop Water Stress Index
DCA	-	Department of Civil Aviation
DN	-	Digital Number
DOS	-	Department of Agriculture Sarawak
EPP	-	Entry Point Projects
GAP	-	Good Agriculture Practice
GCP	-	Ground Control Point
GDP	-	Gross Domestic Product
GEMI	-	Global Environmental Monitoring Index
GI	-	Greenness Index
GLONASS	-	Global Navigation Satellite System
GNDVI	-	Green Normalized Differenced Vegetation Indices
GPS	-	Global Positioning System
GVI	-	Green Vegetation Index
Ig, I3	-	Stomatal Conductance Indices
IR	-	Infrared
JUPEM	-	Department of Survey and Mapping Malaysia
LGM	-	Malaysia Rubber Board
LIGS	-	Sabah Rubber Industry Board

MPC	-	Malaysia Productivity Corporation
MRB	-	Malaysian Rubber Board
MyRTKnet	-	Malaysian Real Time Kinematic Network
NDVI	-	Normalized Difference Vegetation Indices
NIR	-	Near Infrared
NKEA	-	National Key Economic Area
NR	-	Natural Rubber
OSAVI		Optimized Soil Adjusted Vegetation Index
PA	-	Precision Agriculture
PRI	-	Photochemical Reflectance Index
RGB	-	Red, Green, Blue
RISDA	-	Rubber Industry Smallholders Development Authority
RNIR	-	Near-infrared Reflectance
RRED	-	Red Reflectance
RRIM	-	Rubber Research Institute of Malaysia
RVI	-	Ratio Vegetation Index
SALB	-	South American Leaf Blight
SAVI		Soil Adjusted Vegetation Index
SLR	-	Single Lens Reflex
SVI	-	Spectrum Vegetation Indices
TCARI		Transformed Chlorophyll Absorption in Reflectance
TIR	-	Thermal Infrared
UAV	-	Unmanned Aerial Vehicle
VIS	-	Visible band

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The agriculture sector is one of the contributors towards economic development and creates job requirement in Malaysia. It also plays an important role in Gross Domestic Product (GDP). The agriculture sector consists of forestry and logging, oil palm, rubber, livestock, fisheries, aquacultures, and another agriculture crop such as paddy, fruit, coconut, tea, and flowers. The demand towards agriculture products increased as well as the world population hence, gives a great opportunity to expand the contribution of national income and support the Ringgit's foreign exchange valuation (Productivity Report 2014/2015, Malaysia Productivity Corporation (MPC)). However, to fully develop this sector, productivity need to be improved and the operating system needs to be efficient. The available sources such as land, capital, labour and entrepreneurship were fully utilised. Moreover, the knowledge and skill of the workforce were essential to be improved, implement the new technology into the operating system, research and development investment and also human capital and prices.

As one of the important commodity crops in Malaysia, rubber was commercialising for the production of natural rubber (NR) and latex timber. To date, Malaysia is the world's sixth largest producer of NR after Thailand, Indonesia, Vietnam, and China. In 2015, Malaysia has contributed 5.5% to total world raw

rubber supply and RM 20.18 billion to the national export (Department of Statistic Malaysia, 2015). The NR production increased by 4.1% from 0.67 million tonnes (2014) to 0.72 million tonnes (2015), while the NR exports reduced from 1.19 million tonnes (2014) to 1.11 million tonnes (2015). This is owing to the conversion of rubber cultivated area to other crops and economic activities and also replanted rubber cultivated area.

The government has plan strategies to enhance production through the designation of rubber sector as part of the National Key Economic Area (NKEA) with regard to transforming the country into a high-income nation by 2020. There are four Entry Point Projects (EPP) has been designing to be implemented in rubber sector aiming: (i) to increase the average of national rubber productivity, (ii) to maintain rubber cultivated areas at 1.2 million hectares, (iii) to maintain Malaysia as world's biggest producer of rubber gloves, and (iv) to commercialising green rubber that are Epoxidised Natural Rubber (Ekoprena) and Deprotenised Natural Rubber (Pureprena) to substitute the use of synthetic rubber (http://etp.pemandu.gov.my/upload/NKEA_Factsheet_Palm_Oil_Rubber.pdf). These EPPs will improve and enhance the upstream activities, ensure availability of domestic supplies in order to develop higher-valued rubber products.

Currently, the application of remote sensing technologies for crop management has been widely used to increase the efficiency of agriculture input, monitoring crop growth, and health, and also yield estimation. The latest technology for mapping in remote sensing is the unmanned aerial vehicle (UAV) also known as a drone. The UAV is an aircraft without a pilot on board that can be controlled remotely from the ground or flies autonomously based on pre-programmed flight plans or more complex dynamic automation systems. The UAV has been used in agriculture plantation to capturing remote sensing data, counting tree, monitoring hydrology plantation, mapping plantation topography, and field planning. Moreover, monitoring the plantation operations can be done at the same time every month or year and planters can make more proactive decisions in managing the plantation (Antonis *et. al*., 2015).

The mapping concept using UAV platform is basically an adoption of the remote sensing technique whereby a satellite produced a signal with a different wavelength. The wavelengths values depend on particular satellite's instruments. Moreover, different wavelengths were used for different application. Table 1 showed the wavelength of each spectral colour band.

Table 1.1: The spectral colour band characteristic (Source: https://en.wikipedia.org/wiki/Multispectral_image).

No.	Colour Band	Wavelength	Description of Band Utility
1.	Blue	450 – 520 nm	Atmospheric and deep water imaging and can penetrate until 50 m (150 feet) in clear water.
2.	Green	520 – 600 nm	Reacts to the green reflectance of healthy vegetation.
3.	Red	600 – 690 nm	Useful for a vegetation discrimination – chlorophyll absorption band of healthy green vegetation.
4.	Near-Infrared	750 – 900 nm	Very good at detecting and analysing vegetation.
5.	Mid-Infrared	1550 – 1750 nm	Useful in crop drought and plant vigour study – this band is sensitive to the amount of water in plants.
6.	Mid-Infrared	2080 – 2350 nm	Used for discrimination of geological rock formations – identifying zones of hydrothermal alteration in rocks.
7.	Thermal-Infrared	10400 – 12500 nm	Use an emitted radiation for geological structures imaging, thermal differences in water currents, fires, and for night studies.

This study will demonstrate that the UAV can be used as a platform to analyses rubber cultivated areas especially in identifying the physical condition of

the rubber tree. This is due to the conventional and existing technologies which are expensive and unfavourable to smallholders which only depend on human experts. Finally, rubber industry players including research and development sector, smallholders, and estate managers are able to adopt this technology to monitor their rubber cultivated areas.

1.2 Problem Statement

Natural rubber (NR) and rubberwood are the two major products derived from the rubber tree (*Hevea brasiliensis*). The NR is widely used from household goods to industrial products such as tires and latex gloves. Figure 1.1 shows the contribution of rubber industries to national exports from the year 2000 to 2016 (Jan to March).

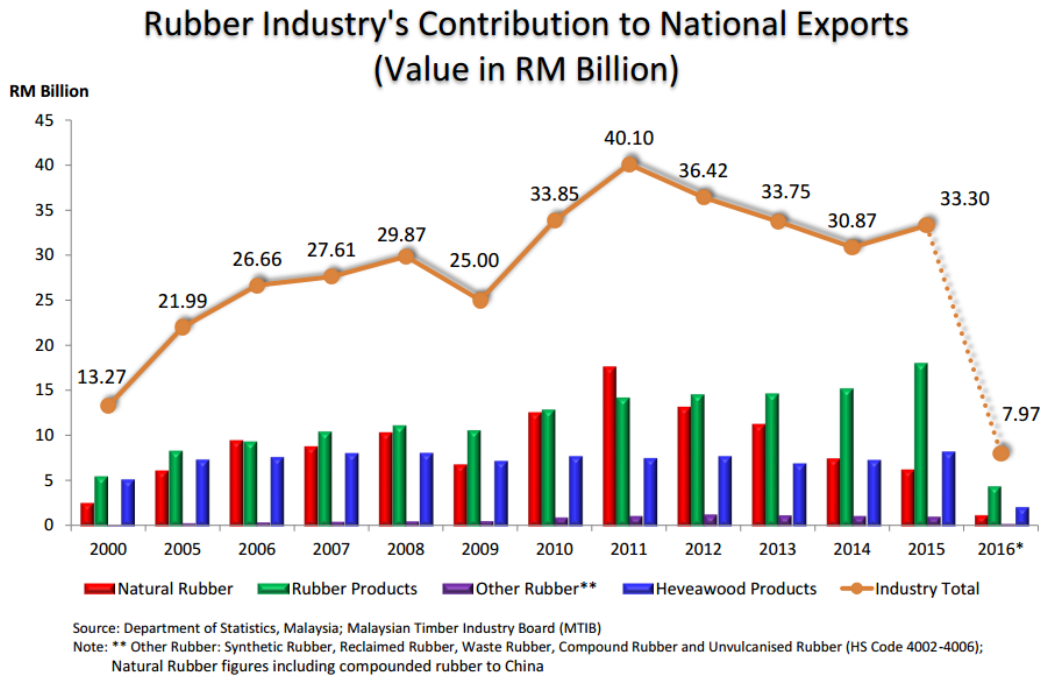
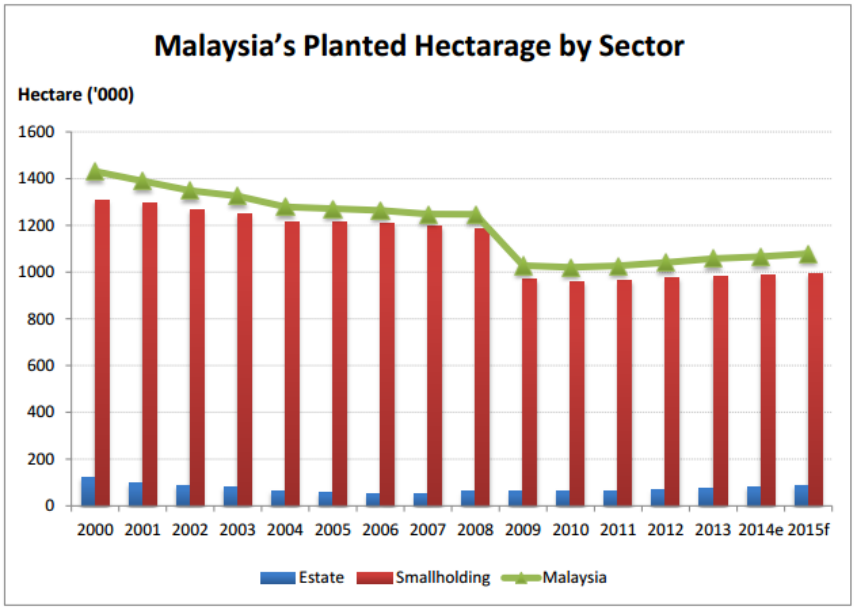


Figure 1.1: The contribution of rubber industry's to national exports (Source: Department of Statistics Malaysia 2016)

Generally, rubber cultivated area in Malaysia was planted by smallholders which are about 92% of total rubber output and the remaining by estates (Figure 1.2). Since the year 2000, smallholders are the largest rubber producer in Malaysia. However, the rubber produced by the smallholders is still low as many of them did not adopt the latest technology, particularly in rubber harvesting due to financial constraint and less confidence of the new technologies (Salmiah, 2013).



e: Estimate, f: Forecast

Figure 1.2: Rubber cultivated area in Malaysia (Source: Department of Statistic Malaysia 2015).

Most of the cultivated rubber trees planted are clones that possess a narrow genetic base whereby limited utilisation of germplasm materials during the breeding process. Consequently, these cultivars are highly prone to pathogens infection, of which *Oidium* leaf disease is a major threat caused by fungus *Oidium heveae*. This disease affects rubber-growing areas resulting in secondary leaf fall of young leaves that emerge after wintering (Min et. al, 2012). *Oidium* leaf disease is predominantly serious in subtropical climate region which is a highly suitable environment for its development. The disease is more serious with high humidity (97 – 100%) and temperatures ranges of 25 – 28ºC. Therefore, by using the advanced technology such

as low altitude remote sensing based on UAV platform would show the disease spread. Moreover, loss of rubber yield is up to 45% and delay in maturity of rubber trees up to three years (Min et. al. 2012). Therefore, a proper, successful and sustainable rubber plantation operation is necessary for monitoring the plantation on a regular basis as the powdery mildew is a significant factor that limiting rubber production area, especially in high humidity areas.

Currently, leaf diseases were observed visually in the field and sampling analysis in the laboratory which is useful for early detection of rubber tree stress to minimise tree loss (Kamaruzaman, 2010). It is known that disease infection is a conjunction of lack of nutrient and inappropriate fertiliser application that contribute to the chlorophyll content and water content in the leaves. In remote sensing technology, chlorophyll content and water content that related to plant nutrition can be detected by the visible and near infrared spectrum. However, an image derived from satellite remote sensing is low of spectral resolution that gives an inadequate calculation of vegetation indices. In addition, timely and accurate information, as well as attractive cost regarding diseases variability of the rubber tree, are required to assist rubber growers (estates and smallholders) in identifying strategies to overcome these problems. Therefore, a continuous monitoring system with low-cost budget and provide fast result is necessary. For that reason, the usage of UAVs to monitoring rubber plantation can be conducted widely and diseases infection can be recognised.

To date, most of the rubber smallholders' do not practice the Good Agriculture Practices (GAP), less skilled or unskilled latex harvester and low adoption of latest technology has contributed to the low latex yield of production. This is due to the limited information and training by the smallholders with modern technology. Therefore, this study is trying to identify techniques to make the management more efficient and the information on phenology become more accurate using the affordable equipment.

1.3 Research Objective

The main objective of this study is to deploy a low-cost UAV platform in order to map rubber disease at clone level and select the suitable method of rubber clones in a different environment. This can be sub-divided into the following specific objectives to achieve the main objective.

i. To observe the rubber disease spectral response curve using handheld spectroradiometer to determine the healthy, unhealthy, and severe infection of *Oidium* leaf disease.
ii. To analyse the spectral response for rubber disease between UAV multispectral images and spectroradiometer field data.
iii. To produce the concentration of rubber disease map based on the correlation between vegetation indices and spectral of UAV and spectroradiometer.

1.4 Scope of the Study

Based on this study, there are few scopes will be covered, namely:

i. This study was conducted at Research Station RRIM, Malaysian Rubber Board, Kota Tinggi, Johor. This area was chosen because it is a rubber plantation area with systematic management and the yield production was recorded properly.
ii. The main instrument will be used in this study are the UAV, compact multispectral camera MAPIR with red, green and blue (RGB) and near-infrared (NIR) sensor respectively. For the spectroradiometer, this study uses FieldSpec HandHeld with the wavelength range between 325 – 1075 nm.
iii. The data involved in this study are the low altitude multispectral images from UAV platform and the spectral reflectance curve based on spectroradiometer.

iv. In the pre-processing, cameras used in this study were examined through the calibration provided by the system to require the calibration information.

v. An orthophoto image was produced based on layer staking procedure to collect the digital number (DN) information. The DN will be used to calculate the normalised difference vegetation index (NDVI).

vi. The processing part involves comparison of data collected from the UAV and spectroradiometer. In order to produced rubber disease map, spectral obtain from the spectroradiometer was used.

vii. The result of comparisons between predicted yield and actual yield was tested using RMSE, t-test analysis, and correlation analysis.

viii. At the end of the study, the correlation between each of the information would be generated in order to analyse the continuity between the information and image analysis from UAV platform.

1.5 Significant of the Study

This study is essential in order to recommend the implementation of monitoring rubber tree in Malaysian Rubber Board (MRB) research station as experimental area using new technology that involves low-cost with a good quality result to increase rubber production. Furthermore, to support MRB boost rubber yield in Malaysia under EPP 9.1: Increasing average national rubber productivity supported by Rubber NKEA's implementing agencies such as Rubber Industry Smallholders Development Authority (RISDA), Sabah Rubber Industry Board (LIGS), and Department of Agriculture Sarawak (DOS). It is also to support MRB mission "To enhance the competitiveness and viability of the Malaysian rubber industries in the global environment through focused research and development, effective transfer of technology and quality support services". In addition, the effective usage of UAV in agriculture monitoring was studied and analyse especially for smallholders, which are low cost and can replace fully remote sensing method high altitude photogrammetry. Finally, this study is to support RISDA mission:

“Establish a progressive society and small farmers prosper through farming and commercial”, by giving some introduction information and awareness among smallholders to stay ahead on the UAV technology.

1.6 Study Area

The study will be conducted at Field 113, Pelepah Division, Research Station RRIM, Malaysian Rubber Board (MRB), Kota Tinggi, Johor (Figure 1.3). The location is at 1° 47.778’ N and 103° 51.343’ E in Kota Tinggi, Johor. The average rainfall is between 2,030 mm to 3,050 mm a year. The range of temperature is between 25ºC to 33ºC.

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. The age of the rubber tree is 10 years. The other area information is stated in Table 1.2.

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 data collection.

This area is chosen because it is well managed for fertiliser and yield by MRB management. The location of the selected trees and ground control points (GCP) is shown in Figure 1.4.

Figure 1.3: Location of the study area

Table 1.2: Study area information for Field 113, Pelepah Division, Kota Tinggi.

Field 113, Pelepah Division, Kota Tinggi.		
Location Information	State	Johor
	District	Kota Tinggi
	Location	Pelepah Division, MRB
	Area	9.4 hectare
	Date of planting	August 2006
	Planting distance	3.6 m x 6.0 m
	Lot area (Source: GoogleMap)	

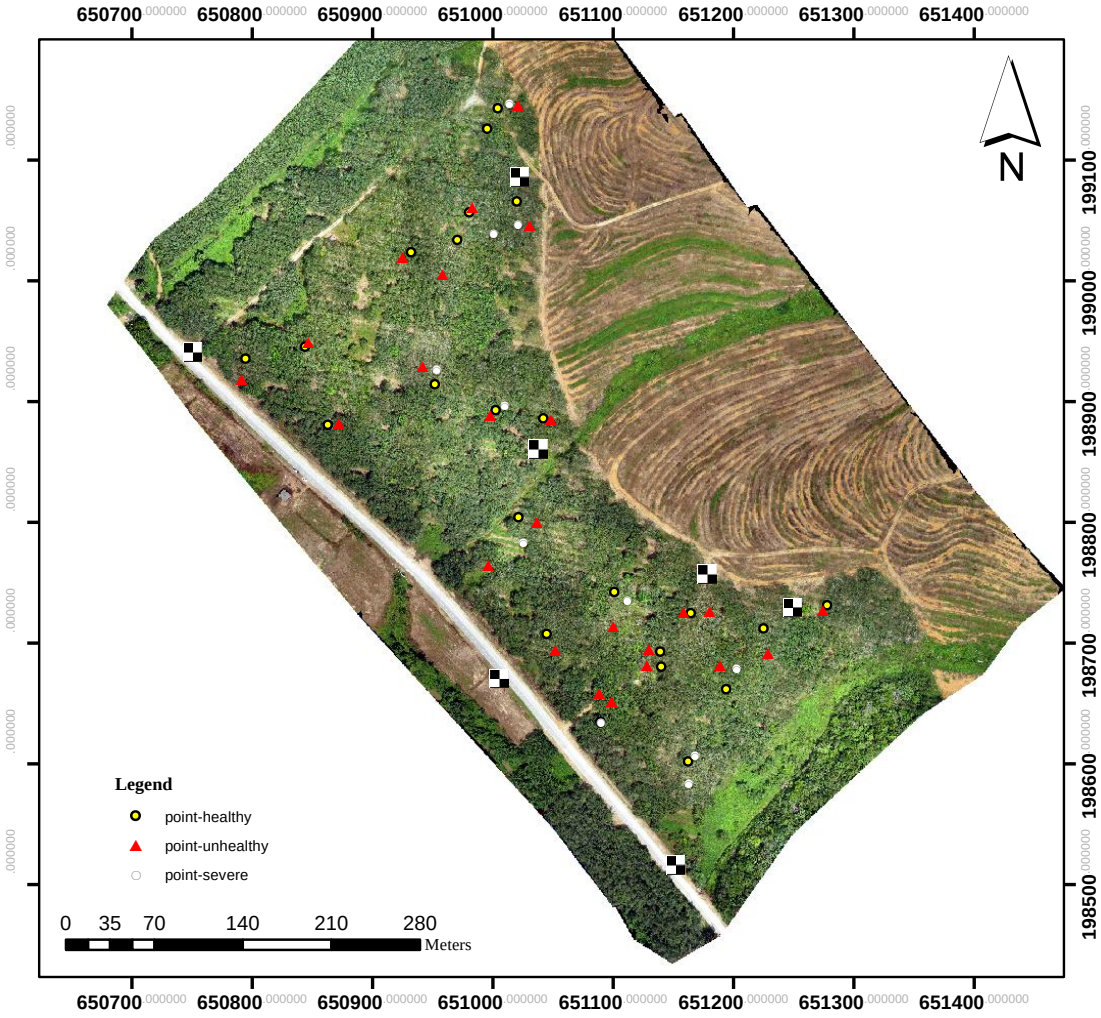


Figure 1.4: Location of selected samples (○, ▲ ,●) and the location of Ground Control Points (▪) in Field 113, Pelepah Division, Kota Tinggi.

1.7 Structure Thesis

This thesis comprises five chapters that provide an understanding of the research questions and objectives to be achieved.

In the first chapter, basic information about rubber plantation, UAV technology will describe including the research background, research problem,

research objectives and questions, research design and the benefit of the study conducted. This will present the entire structure of the thesis.

Chapter two consist a general briefing and exploration about the study through revision of the earlier study that had the same concern with this study. This chapter would focus on the background of UAV, UAV for vegetation studies and study in rubber using UAV.

Chapter three presented the methodology process that had been taken in this study. It covers the process of all the phase and explained deeper about data acquisition, pre-processing and processing structure.

Chapter four is dealing with data analysis and the results of the study. It would present the data collected from the study area and also the development of the correlation spatial variability of rubber using yield production, fertiliser and spectral analysis. Finally, the conclusion and recommendation of the research are detailed in chapter five. Conclusions made are based on the overall of the studies and the experienced faced in this study. The recommendations also provided in order to assist further study for the future.

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