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FIELD SPECTROSCOPY FOR DETECTION OF *Ganoderma* DISEASE IN OIL PALM

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MPOB INFORMATION SERIES • ISSN 1511-7871 • JUNE 2013 MPOB TT No. 532

The Basal Stem Rot (BSR) disease caused by *Ganoderma boninense* has caused huge economic losses to oil palm plantations (Roslan and Idris, 2012). The disease can be diagnosed based on the presence of basidiomata of the pathogen on the stem base or frond bases or roots (Idris and Ariffin, 2004). Several technologies have been developed for the detection of the *Ganoderma* disease in oil palm, namely *Ganoderma* Selective Medium (GSM) (Ariffin *et al.*, 1993); Polyclonal Antibodies Enzyme-Linked Immunosorbent Assay (PAbs-ELISA) (Idris and Rafidah, 2008); Multiplex PCR-DNA Kit (Idris *et al.*, 2010); and GanoSken Tomography (Idris *et al.*, 2010). Another technology known as field spectroscopy can also be used for the detection of *Ganoderma* disease in oil palm. Field spectroscopy is a hyperspectral remote sensing (HRS) technique that provides non-destructive measurement to differentiate healthy and infected oil palm (Izzuddin, 2010; Shafri *et al.*, 2011; Nishfasriza, 2012). The field spectroscopy technique refers to the application of a hand-held spectroradiometer to retrieve spectral reflectances from oil palm canopy and leaves. Spectral reflectances are measured as percentages of reflectances from the oil palm canopy and leaves after the illumination of sunlight within a certain spectrum range.

OBJECTIVES

1. To identify significant wavelengths suitable for the detection of *Ganoderma* disease in oil palm.
2. To develop a field spectroscopy system for the detection of *Ganoderma* disease in oil palm.
3. To assess the accuracy of the field spectroscopy system for the detection of the *Ganoderma* disease in oil palm.

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METHODOLOGY

The field spectroscopy system (*Figure 1*) used consisted of a spectroradiometer sensor, white reflectance calibration, fibre optic cable and data processing software called Oil Palm Spectral Analyser System (OPSAS).

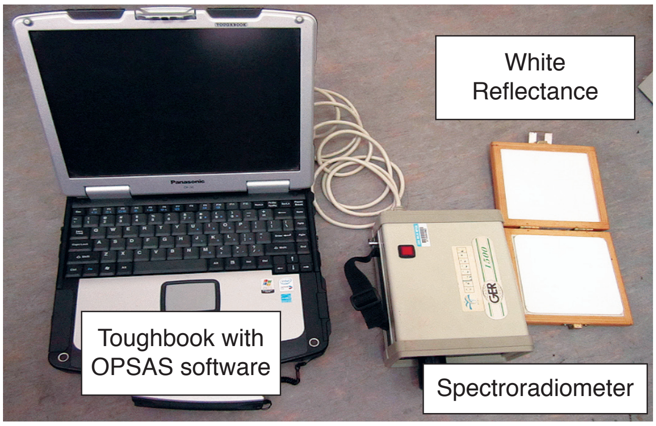

Figure 1. Field spectroscopy system.

The samplings were conducted at the canopy-level of immature oil palm and at leaves-level of young and mature oil palm (*Figure 2*). The palms were initially confirmed to be infected by the *Ganoderma* disease using GSM. Spectral reflectances were acquired from over 512 wavelengths from 273.13 nanometer (nm) to 1099.57 nm with an average spectral resolution of 1.6 nm. The spectral reflectances measured from oil palm were calculated using the following equation:

$$\text{Reflectance}_{\sigma,\theta} = \frac{\text{Target Radiance}}{\text{Panel Radiance}} \times \begin{array}{l}\text{panel calibration} \\ \text{Bidirectional} \\ \text{Reflectance} \\ \text{Factor (BRF)}\end{array}$$

The spectral reflectances data for healthy and infected palms are presented in *Figure 3*.

ISSN 1511-7871
9 771511 787001
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Figure 2. Data measurement using a field spectroscopy on (a) immature young and (b) mature oil palm.

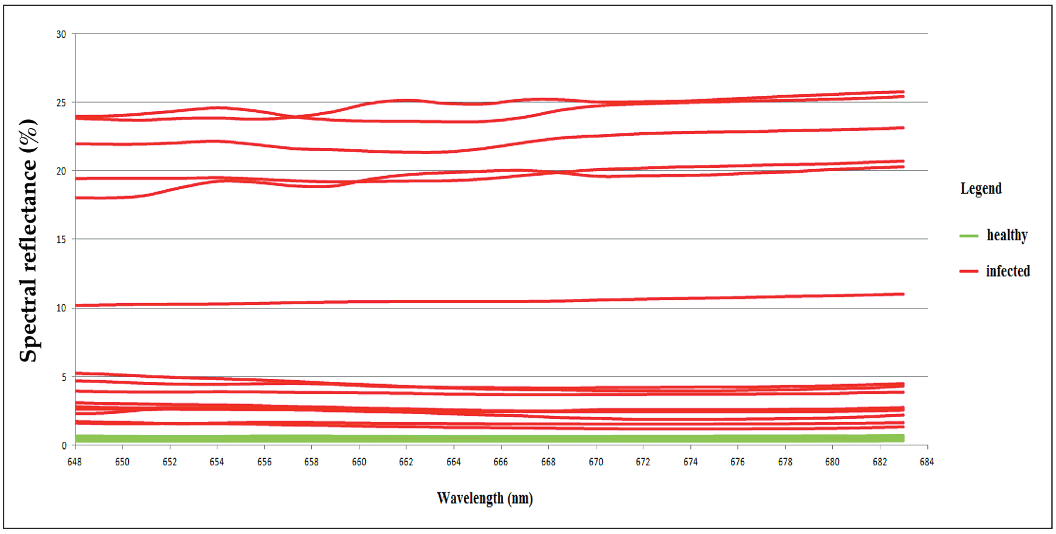

Figure 3. Spectral reflectances (648 nm – 682 nm) of healthy (green lines) and infected oil palms (red lines).

The spectral reflectances were processed and transformed into the first derivative of spectral reflectances. Analysis on the first derivative of spectral reflectance by Nishfariza (2012) had identified 662 nm as a significant wavelength for *Ganoderma* disease detection on immature, young and mature palms. Data transformation and analysis were conducted using the OPSAS software (*Figure 4*).

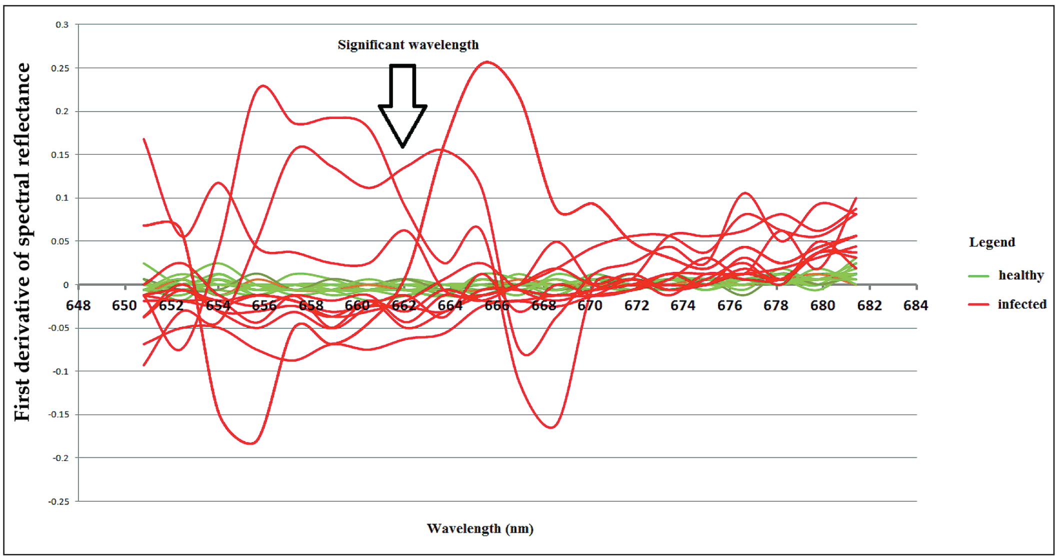

Figure 4. First derivative of spectral reflectances (648 nm – 682 nm) of healthy (green lines) and Ganoderma *infected oil palm (red lines).*

Table 1 summarises the descriptive statistics of first derivative of spectral reflectance values at 662 nm that were used for the detection of *Ganoderma* disease in oil palm.

TABLE 1. DESCRIPTIVE STATISTICS OF FIRST DERIVATIVE OF SPECTRAL REFLECTANCE VALUES FOR HEALTHY AND *Ganoderma* INFECTED OIL PALM

Class	Mean	Min	Standard deviation	Max
Healthy	-0.00788	-0.0448	0.0118	0.00621
Infected	-0.00488	-0.155	0.0543	0.137

The field spectroscopy technique was tested in the field. The results showed that 35 out of 40 immature palms, 48 out of 60 young palms and 45 out of 60 mature palms were correctly detected by the field spectroscopy technique (*Table 2*). The field spectroscopy results were compared to the GSM technique prior to the field spectroscopy technique.

CONCLUSION

Hyperspectral remote sensing using the field spectroscopy technique is able to differentiate between healthy and *Ganoderma* infected palms. The OPSAS software helped to reduce the data processing time. This technique assists the management and control of *Ganoderma* in oil palm plantations.

TABLE 2. A COMPARISON OF THE *Ganoderma* SELECTIVE MEDIUM (GSM) AND THE FIELD SPECTROSCOPY FOR THE DETECTION OF *Ganoderma* DISEASE IN OIL PALM

Oil palm age	Total number of diseased oil palms confirmed by GSM	Total number of diseased oil palms detected by field spectroscopy	Accuracy (%) of field spectroscopy against GSM technique
Immature (2 years)	40	35	87.5
Young (5 years)	60	48	80.0
Mature (17 years)	60	45	75.0
Total	160	128	80.8

The results suggested that the accuracy of field spectroscopy was higher for immature oil palms than young and mature palms. The first derivative of spectral reflectances value at 662 nm, which was significant for the detection of *Ganoderma* disease in oil palm was confirmed to be different from the wavelengths and spectral values of 570 nm, 680 nm, 734 nm, 787 nm, 996 nm and 1047 nm that have been used for the detection of bagworm infection in oil palm (Nordiana *et al.*, 2012). In remote sensing, a 100% accuracy is almost impossible, due to changes in the environment and field conditions.

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