Journal of Sustainability Science and Management
Volume 9 *Number* 2, December 2014: 52-57
ISSN: 1823-8556

DETECTION OF BASAL STEM ROT DISEASE AT OIL PALM PLANTATIONS USING SONIC TOMOGRAPHY

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Abstract: *Ganoderma boninense* cause basal stem rot (BSR) disease to oil palm in Malaysia. It is the most serious disease of oil palm in Malaysia where 3.5% of plantation areas infected render lost in revenue of RM 1 billion/year. Detection of BSR is challenging because the external symptoms do not appear at early stages of infection. To date, common methods used to detect BSR disease are morphological and molecular techniques. These techniques are costly and time-consuming. This study aims to identify, quantify and classify BSR lession using tomography. A total of 51 palms with BSR visual symptoms and neighbouring palms were selected and scanned using PiCUS Sonic Tomograph. Samples from the trunks were digged-out using increment borer and tested on Ganoderma selective medium (GSM) for detection purposes.Tomograph result revealed that there were two trees with 0% damaged, nine trees with 1-20% damaged, 19 trees with 21-40% damaged, 15 trees with 41-60% damaged and six trees with 61-100% damaged. In addition, Ganoderma selective medium reconfirms that 49 out of 51 trees have been infected with BSR disease indicating tomogram accuracy of detecting BSR is 96%. Accuracy assessment also revealed that tomography is able to determine BSR severity level at 82%. Hence, the application of tomography in detecting *Ganoderma* infection is pertinent for oil palm plantation management to treat the oil palm accurately and effectively.

KEYWORDS: Tomography analysis, oil palm, basal stems rot, *Ganoderma*, detection.

Introduction

Malaysia has the second largest oil palm plantation in the world, with a total area of 5.07 million ha in 2012. Plant health is crucial in obtaining maximum production. In Malaysia, the oil palm plantations are blessed by being largely disease free, except from one major disease, BSR caused by *Ganoderma* species. The disease is considered as the most serious disease in Malaysia and some estates in South East Asia (Idris *et al.,* 2000 a, b; Susanto *et al.,* 2005; Susanto, 2009) where the losses can reach up to 80% after replanting.

External symptoms of *Ganoderma* infection usually observed on the leave condition and growth of fruiting body from the tree trunk. Utomo *et al.,* (2005) mentioned that *Ganoderma* infection in oil palm occur from the second and subsequent planting cycles. Detection of BSR is based on the occurrence of unopened oil palm spear leaves and basidiocarp of the fungus appearing on the trunks or primary roots near soil level (Mohd As'wad *et al.,* 2011). The basidiocarp is the most identifiable structure associated to the fungus. The conk originates from the fungus that grows in the infected trunk. However, most of the time the conk does not appear at the early stage of the infection, making early detection of the disease very difficult (Mazliham *et al.,* 2007).

The disease can be infected in all growing stages of oil palm plants. Previously, the disease was found in older palm but currently it is also found in younger palm as young as 1-2 year olds (Laila *et al.,* 2011). In early stages of infestation, infected palms usually appear symptomless. The fungus may grow internally before symptoms can be visually observed. Laila *et al.,* (2011) added that once the symptoms appeared physically, more than half of the bole tissues were decayed. BSR disease infection spreads from the palm roots and gradually spread to the bole of the stem, causing dry rot, thus preventing water and nutrients from being absorbed by the soft tissues and transported to the top of the palm tree.

However to date, a few methods based on biochemistry processes are used to detect *Ganoderma* infection such as a polymerase chain reaction (PCR) and enzyme linked immunosorbent assay (ELISA). However, these methods require the stem collection for further tests in the laboratories (Idris *et al.,* 2007) which bring to inefficiency use of time and cost. The ability to perform an early detection of the infection will enable the palm to be treated at the early stage of the infection and thus avoiding more extensive damage on the palm. According to Idris A. S. (personal communication, 2011), fruiting body of *Ganoderma boninense* emerge when the damage level of the infected tree is above 30%. Hence, if detection can be done at early stage of infection range between 0-10% or up to 25%, the infected palms can be saved.

In recent years, the possibility of applying to standing trees the non-invasive techniques which are typically used for industrial products have stimulated the interest of scientists and some methods based on sound velocity measurements have been introduced in the practice of tree assessment (Mattek and Breloer, 1994; Sandoz *et al.,* 2000; Deflorio *et al.,* 2008; Li *et al.,* 2012; Niemtur *et al.,* 2013).

This study utilises a sonic tomography instrument called PiCUS Sonic Tomograph. The instrument consists a set of sensors that are strategically placed around a tree trunk to detect the internal lesion of BSR. Apparent sound velocities were calculated based on the times of sound waves flight (by knocking PiCUS Electronic Hammer on a placed nail) and the distance between sensors. This calculation is repeated on all nails around the tree.

The data were then displayed into a tomogram with three (3) categories of colours indicating a healthy or solid wood (black / brown), decrease in densities (green) and degraded wood (violet / blue / white). The entire colours are categorized based on the different velocities of the sound wave. By understanding the tomogram, the status of a tree whether it is healthy, decrease of density or unhealthy can be promptly determined. This paper is to identify, quantify and classify the BSR disease and also to investigate the capability and accuracy of tomograph.

Methodology

Study Area

The study was conducted at Kretam Oil Palm Plantation, Sabah, Malaysia with 5°38'N, 117°51'E coordinates, 70 kilometres from Sandakan city. The total area of 6840.67 hectares were planted with oil palm trees and divided into two estates namely Masang and Kuala Bode Estate.

Collection of Tomography Data of Each Oil Palm Trunk

Total of eight infected palms (with the presence of *G. boninense* basidiocarp and foliar symptoms) were chosen as focal point where each point consists of six to seven suspected infected neighbouring palms. All 51 chosen trees were scanned with a sonic tomography at 1 meter high from the ground (BSR disease spread from the ground) to produce tomogram. The tomogram were classified into 5 classes of severity level of damage i.e. 0%, 1-20%, 21-40%, 41-60%, and 61-100%. Figure 1 shows example of tomogram of a tree, generated by PiCUS sonic tomography detector:

(i) Different severity levels of damage
(ii) Early stages of wood volume degradation
(iii) Location of damage in the trunk

Verification Using Ganoderma *Selective Medium*

GSM provides a useful tool for isolating *Ganoderma*, free from other contaminants. The content of fungicides and antibiotics in GSM is

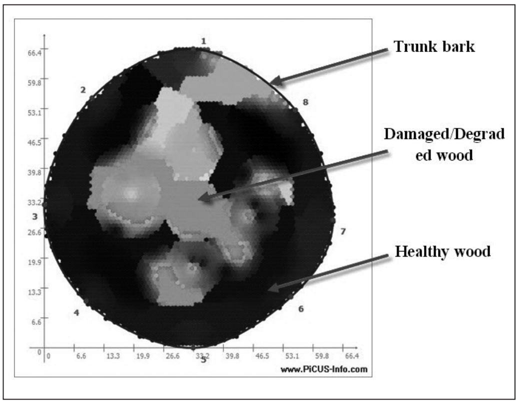

Figure 1: Example of Tomogram of a Palm Tree Internal Condition

optimal to control growth of bacteria and other contaminating fungi, while allowing *Ganoderma* to thrive. This method of verification is more appropriate and proven to be affective in term of its accuracy.

Internal trunk sample of all 51 chosen palms (scanned with sonic tomography) were excised at the same spot of mounted sonic tomography sensor using an increment borer (Figure 2) from four different directions of north, south, east and west of the tree. The directions of excised point were recorded to verify the location of damaged given by sonic tomography.

Samples excised from the bottom part of trunk were isolated and cut into five equal portion of 2 mm and subsequently cultured on

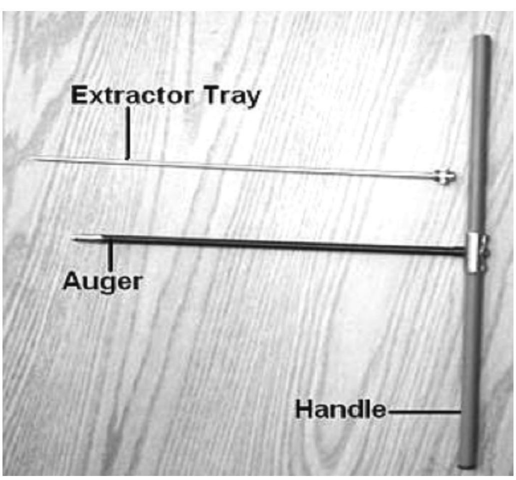

Figure 2: Increment Borer Device

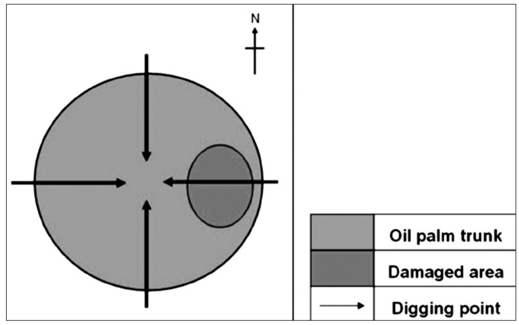

Figure 3: Cross-section of an Oil Palm with Digging Points

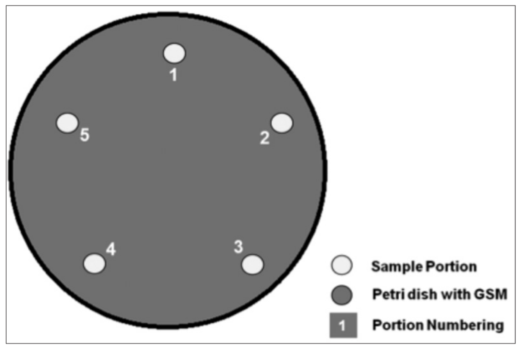

Figure 4: Sample Portion Arrangement on GSM

GSM in a clockwise circle at equal distance (Figure 4). Each palm has four GSM (from four directions) with five portions of samples respectively. Therefore, all 20 portions resemble a palm tree internal condition. The mycelium of *G. boninense* which succesfully grew on the GSM were counted and recorded after five days.

Results and Discussion

Reading of Sonic Tomography

Table 1 shows that from eight focal trees, two trees have 21-40% severity level of damage, four trees with 41-60% and two trees with 61-100%. All focal trees are visually observed having basidiocarp (fruiting body) on the tree trunk. As mentioned by Mazliham *et al.,* (2007), the basidiocarp would not appear at early stage of infection. Therefore, tomograph is proven to be able to determine correctly the severity level of damage of BSR disease where all the severity level calculated by tomograph was all in the late stage of infection.

Table 1: Tomograph Reading of 8 Focal Trees (with Basidiocarp Presence)

Severity Level (%)	No. of Tree
0	0
1 – 20	0
21 – 40	2
41 – 60	4
61 – 100	2
Total	**8**

Table 2: Tomograph Reading of 43 Neighbouring Trees (with No Basidiocarp Present)

Severity Level (%)	No. of Tree
0	2
1 – 20	9
21 – 40	17
41 – 60	11
61 – 100	4
Total	**43**

Meanwhile, Table 2 shows that from 43 neighbouring focal trees, two trees were found to have no damage, nine trees with 1-20%, 17 trees with 21-40%, 11 trees with 41-60% and four trees were with >61% damage. This indicated that 41 out of 43 (95%) trees nearby focal trees suspected to have been infected with BSR and tomograph was able to detect even at early stage of degradation of wood volume (1-20% infected). This research found that 32 out of 43 neighbouring trees were severely damaged internally above 21% but there are no basidiocarp found. This shows that the trees were already severely damaged inside even though with the absence of basidiocarp. Hence, tomograph proves to be able to detect damages even there are no basidiocarps shown.

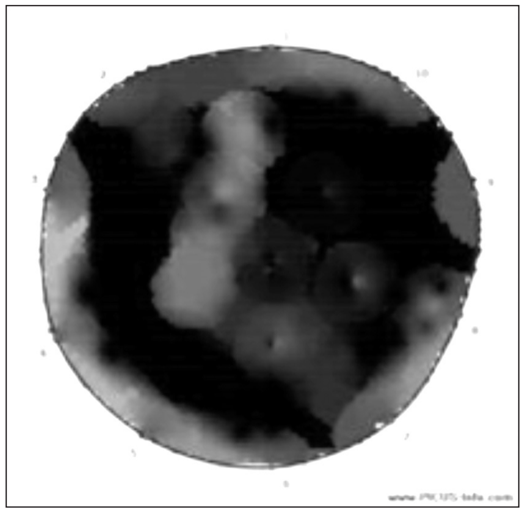

Figure 5: Tomogram of a Healthy Tree (0% damaged)

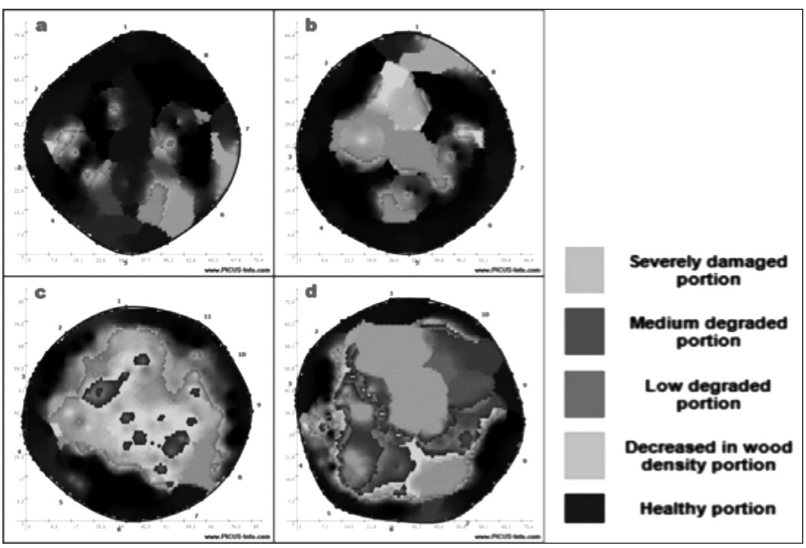

Figure 6: Tomogram of Tree With (a) 5% damaged, (b) 22% damaged, (c) 46% damaged, and (d) 64% damaged

Figure 5 shows an example of tomogram of a palm with 0% damaged which was classified as a healthy tree. The palms show no external symptoms of BSR. As shown in Figure 6, four examples of palms were arranged respectively to their percentage of damage.

Table 3: Output Test of Accuracy Assessment on BSR Severity Level

	Ganoderma Detected			
Severity Level (%)	**No. of Tree (Tomograph)**	**No. of Tree (GSM)**	**Accuracy (Correct)**	**Accuracy* (%)**
0	2	0	0	0
1 - 20	9	3	3	33
21 - 40	19	28	19	100
41 – 60	15	14	14	93
61 – 100	6	6	6	100
Total	**51**	**51**	**42**	**82**

*Accuracy (%) = (Accuracy (Correctly diagnosed) / No. of tree (Tomograph)) x 100

Accuracy Assessment

GSM reconfirms tomograph detection of all 49 trees having BSR to be accurate. However, two trees found to be healthy (no basidiocarp) by tomography was verified as infected with BSR by GSM. Therefore, accuracy of BSR detection is 49 out of 51 (96%). While for severity level, GSM verified 42 out of 51 trees correctly diagnosed is 82% correct. Severity level of damage at tomogram was determined automatically by the PICUS software. However, severity level of existence at GSM was determined by calculating percentage number of trunk sample portion with *G. boninense* mycelium growth on GSM. Table 3 shows the output test accuracy assessment.

Conclusion

This study reveals that PiCUS Sonic Tomograph is proven to be reliable for field detection with 96% accuracy in detecting BSR disease. Accuracy assessment shows that overall severity level was 82%. Improvement on method focusing on tree selection, data collection and verification is necessary in order to achieve early detection of the disease. However, rainy weather restricts the operation of PiCUS Sonic Tomograph and a rain proof device could be helpful.

Acknowledgements

Thank you to all personals from Kretam Oil Palm Plantation, Sabah and Aeroscan Precision Sdn. Bhd. and Universiti Putra Malaysia for providing the research grant.

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