Digital Plantation story of RGE

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Abstract – This article highlights the digital plantation story of Asian Agri palm plantation business. The focus of this article shall be on the key challenge faced by the Asian Agri in the management of ganoderma fungi infestation in its palm plantation, and the current utilization of digital technologies and further possible enhancements to enable earlier detection of the ganoderma infestation so that better treatment and overall containment of the infestation can be performed to significantly minimize the impact to harvest yield.

Index Terms—digital plantation, digital agriculture, plantation management system, plantation, palm tree, hyperspectral imaging, ganoderma.

1 INTRODUCTION

Established in 1979, Asian Agri spearheads Royal Golden Eagle (RGE)'s palm oil operations and is currently one of Asia's largest palm oil producers with an annual production capacity in excess of 1 million tons, and manages more than 160,000 hectares of palm oil plantations. The findings and recommendations of this article are done via interviews with relevant mill personnel and palm management system owners, as well as other relevant research on the topic of early detection of ganoderma fungi infestation and its management. [1]

2 KEY CHALLENGE OF GANODERMA INFESTATION AND ITS IMPACT

Managing more than 160,000 hectares of palm oil plantations, Asian Agri faced a number of key challenges, the most critical of which is the management and containment of the Ganoderma fungi infestation.

There are several different species of Ganoderma fungi, such as Ganoderma Heterobasidion, Pleurotus, Lentinus, but it is Ganoderma boninense which has been identified as the major cause of the fungi disease of oil-palm trees. The fungi causes the deadly Basal Stem Rot (BSR) disease, wood-decay and butt rot in oil-palm trees. It is known as the most destructive disease of oil palm plantations in Southeast Asia. It is responsible for a significant portion of oil palm losses, estimated at US$500 million a year in Southeast Asia. [2]

And as pointed out by (Camille et al, 2010), the detection of ganoderma fungi in crops such as palm trees, represents a major issue in palm estate management. Current detection & diagnostics method via direct visual symptom observation is difficult and time-consuming, while other methods such as those based on root or stem tissue chemical analysis are very expensive and damaging. [3]

3 CURRENT GANODERMA INFECTION DETECTION & MANAGEMENT

As part of its effort to track the results visual observation census, verification, final inspection and subsequent treatment & containment of Ganoderma infestation, Asian Agri has developed the Asian Agri Connected Plantation (AACP) digital platform [4]. The AACP include the field-force mobile data capture application using tablets plus dashboarding and alerts capabilities at the Plantation Operations Control Center.

Currently, the method to detect Ganoderma infestation is via direct visual symptom observation by plantation workers. Assigned plantation workers will inspect every tree within their assigned area / plots called afdeling. They will then record their visual symptoms observations into the AACP field force application using tablets. The visual observation that are recorded include the symptoms of a potential or confirmed ganoderma infection [5], such as:-

Tree Part	Visual Symptoms
Fruit	Reduced fruit size.
Leaves/Fronds	Abnormal colors, forms, necrotic areas on leaves, Wilting, yellowish fronds.
Roots	Fungal growth on root surface, wood rot, soft rot of cortex.
Stems	Bark discoloration, mold growth on lesion.

Table 1.0 – Types of symptoms due to Ganoderma infection.

Visual observation data that is recorded shall then be updated back to the server via wireless connection at the Plantation Operations Control Center. Updated data will then be visible via the AACP's Pest & Diseases (P & D) Control Dashboards. Fig 2.0 shows the P & D Control Dashboards dashboard with the blue bar indicating the total number of trees confirmed to be positively infected, while the red bar indicating the total number of trees that shows signs & symptoms of potential infection taking place.

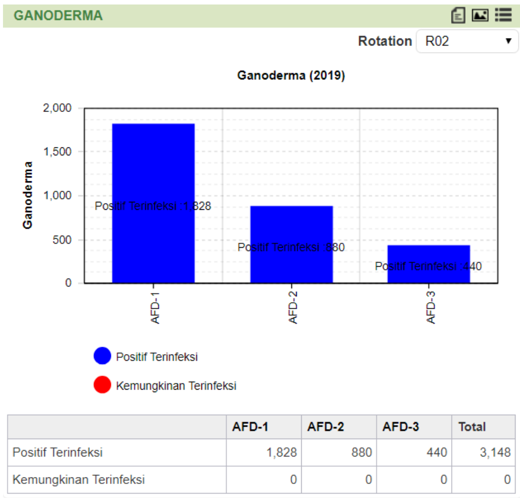

Fig 2.0 – Dashboard displaying the total number of trees exhibiting visual symptoms of ganoderma infection in each afdeling.

A tree is recorded as possibly infected if it shows 3 or more visual symptoms highlighted in Table 1.0, possible infection requires further verification to confirm there is a positive infection on those trees, the result of the verification and whether the symptoms show that the tree has to be removed to contain the infection is also recorded via tablet and also displayed in the AACP P & D Dashboard, refer Fig 3.0.

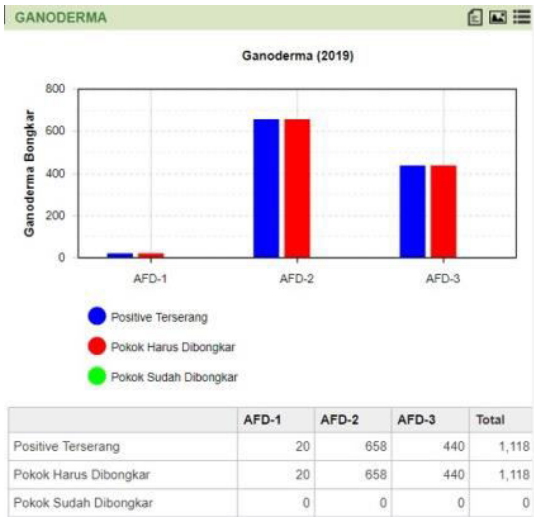

Fig 3.0 – Dashboard displaying the total number of trees confirmed to be infected by Ganoderma (blue bar) and number of trees to be removed to contain the infection (red bar) in each afdeling.

Although, the AACP digital platform enabled Asian Agri to track the trees infected by Ganoderma based on visual symptoms, those visual symptoms such as the appearance of the fruiting body, refer Fig 4.0, is difficult to spot and only appears at a late stage of the infection. Once the fruiting body is visible, the infection has reached a late stage where the entire palm tree has to be removed in order to contain the disease from spreading to surrounding areas as a result of the spores released by the fruiting body. Furthermore, even the stump and root system needs to be removed together with the tree, to further contain the infection.

Fig 4.0 –Fruiting body observed on the trunk of the tree from Ganoderma infection

If not detected early, death may occur to trees infected by the Ganoderma, within 6-12 months, with the fatality rate of up to 80% of affected trees. Due to Ganoderma infection, the Fresh Fruit Bunch (FFB) yield is estimated to be reduced by an estimated 0.04t/ha to 4.34t/ha, refer Fig 5.0. Also, the fungi survives in the soil even when treated, continuous monitoring is crucial because as many as 30% of the replanted areas may be affected within 1-2 years of replanting. [6] Thus it is crucial to employ alternative methods, which we shall look at in the subsequent section, to detect the infection earlier so that effective management of the infection can be performed.

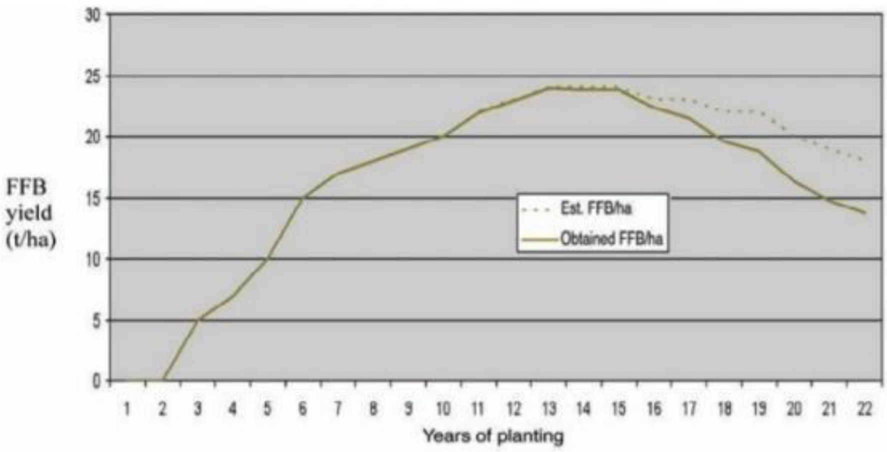

Fig 5.0 – Reduction in FFB yield due to Ganoderma infection.

4 EARLIER DETECTION OF GANODERMA INFECTION

Currently, there is no single method that is able to halt the continuing spread of this deadly disease. It is therefore crucial to identify and select the methods for early detection of the fungi infection. Currently, there are a few early detection methods [7], such as:

- Hyperspectral Imaging (via remote sensing using digital imaging and spectroscopy).
- Biochemical method.
- Chemical method (via the detection of the presence of the Ganoderma chemical compound in the trees).

4.1 Hyperspectral Imaging for ganoderma detection

Hyperspectral imaging (or remote sensing) combines digital imaging and spectroscopy (the study of the interaction between matter and radiated energy). Hyperspectral imaging involves capturing images over several spectrums, for example: visible light, Near Infrared, Infrared. Using hyperspectral imaging tools, the image and reflectance data captured exhibits a clearly distinguishable difference, refer Fig 6.0, and Fig 7.0, in between healthy trees and those infected by the Ganoderma fungi.

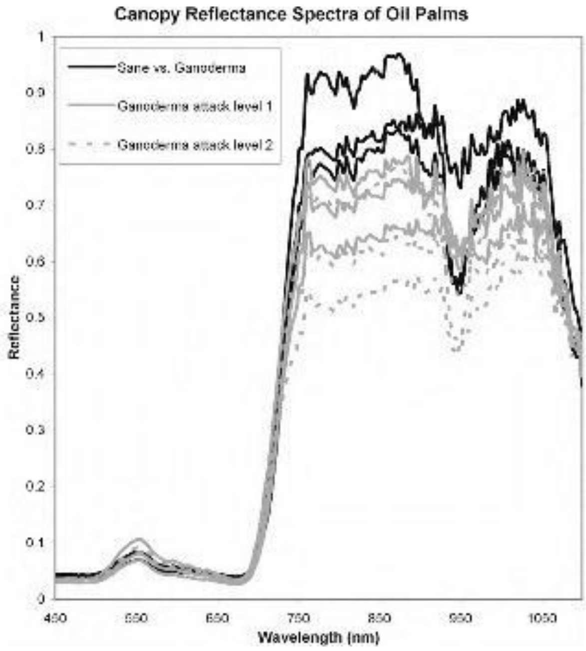

Fig 6.0 – Distinctive reflectance profiles generated from healthy and ganoderma-infected trees.

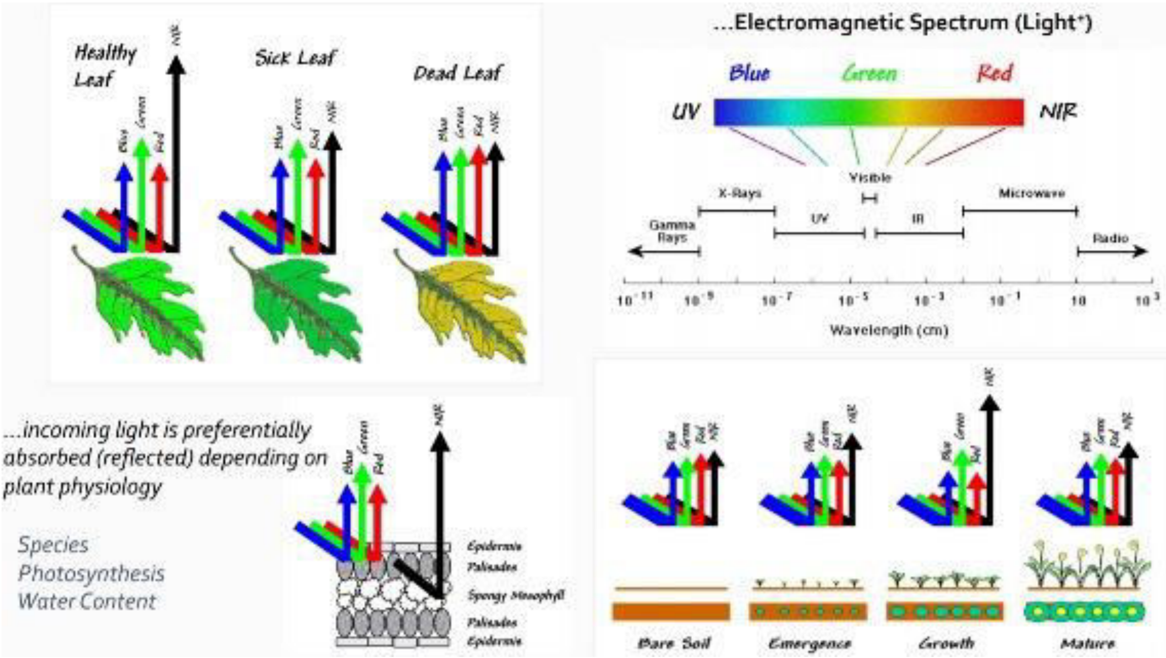

Fig 7.0 – Reflectance data captured using remote sensing enables early detection of infection symptoms such as sick or dead leaves.

As imaging and data acquisition tools, plus other technologies like Unmanned Aerial Vehicles (drones) gets more reasonably priced, the tools used to capture the data has gone from using handheld spectroradiometer (a device to measure spectral reflectance ratio of incident-to-reflected light measured from an object over specified wavelengths) in 2008, to Hyperspectral Data acquisition using UAV (drones customized to carry sensors for hyperspectral data acquisition sensors) on young and mature palm, over large plantation areas [8].

Fig 8.0, adapted from various sources [9],[10], highlights the key technologies used for Hyperspectral Imaging (remote sensing):

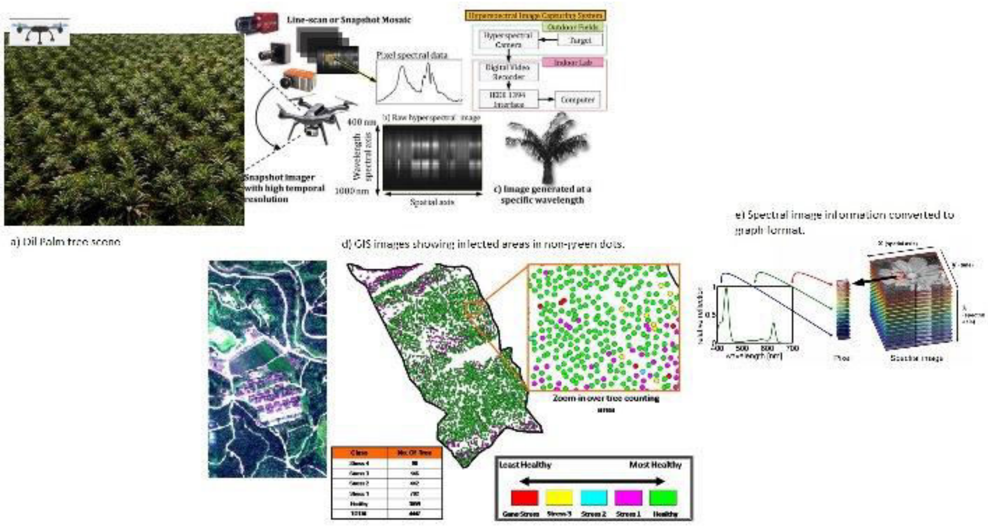

Fig 8.0, highlight the key technologies used for Hyperspectral Imaging (remote sensing)

(a) Hyperspectral data UAV (drones) fitted with Hyperspectral Cameras and Geographic Information System (GIS) technologies shall capture the required data based on the flight path planned.
(b) The resulting data in the forms of raw hyperspectral image are then made available when synched back to the Plantation Control Center servers.
(c) An image of the tree is also made available based on the different wavelengths captured (e.g. Near Infrared or NIR).
(d) Together with GIS data, the overall infected vs. healthy areas of the plantations can be plotted.
(e) Hyperspectral information in the form of hyperspectral data cube (data in 3-dimension: x and y spatial information, plus spectral wavelength information), can also be converted to graphs for deeper analysis.

The rapid progress of Hyperspectral imaging or remote sensing method & technologies for ganoderma infection, coupled with more competitively-priced UAVs fitted with advanced hyperspectral cameras, and leveraging on GIS technology allows for faster imaging and data-capturing rate of estimated 500 ha/day for 1 UAV), the data provides quick visualization and also opportunities to perform advanced data analytics on them to make prediction and to guide future actions in disease management in the plantation. Based on an earlier study, it is possible to detect ganoderma infection in trees in more than 90% of the cases with the hyperspectral imaging method [11], thus this method should be considered based on the various benefits it has over the others.

4.2 Biochemical Method for ganoderma detection

Biochemical method based on immunoassays called enzyme-linked immunosorbent assay (ELISA). Using this method, biological substances (antigens) specific to G. boninense taken from the tree sap, reacts with antibodies that are made to detect it, and a detectable signal is emitted usually in the form of color change. This method suffers from reliability issues as there are major drawbacks such as the high rate of obtaining false positives (due to reaction of antibodies happens even with antigens from unrelated fungi species) or false negatives. [12]

4.3 Chemical method for ganoderma detection

Ganoderma infection can be detected via the presence of ergosterol (a type of chemical compound that are part of the cell membrane of the ganoderma fungi) in the infected tree. To do this, a small sample can be taken from the tree stem or trunk by drilling. Next, there must be a way to extract the ergosterol (which is invisible to the eye), and then proceed to separate it from the other organic molecules using a combination of physical and chemical method. Once separated, the presence of ergosterol can then be detected. Although there is an ergosterol detection kit which employs the Thin Layer Chromatography (TLC) method to detect the presence of ergosterol via immersing the crushed samples into a special solvent, which together with the TLC plate will show the presence of ergosterol under the ultraviolet (UV) lamp. [13] The challenge of this method is that it requires quite a huge amount of physical work to extract the samples from each tree by drilling (which is also destructive), and then further work would be required to perform the separation via chemical work by trained personnel before the detection of ganoderma through the presence of ergosterol is possible.

5 CONCLUSION

The Basal Stem Rot disease caused by Ganoderma infection is deadly to oil palm trees, so it is crucial to identify and select effective early detection methods & technologies that are fast, accurate, reliable, reasonably-priced & practical on the field. Once detected, proper treatment has to be carried out and post-treatment monitoring measures, such as via Internet of

Things (IoT) sensors [14], needs to be in place to ensure that the treatment is effective. In summary, there is work to be done in the selection and implementation of effective detection & post-treatment monitoring methods and technologies. The methods & technologies chosen should integrate well with the AACP digital platform, for earlier detection, better treatment and overall management of the disease. And this will ensure the sustainability of the palm oil plantations managed by Asian Agri.

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About the authors

Mr. Abhishek Singh is the Chief Digital Officer of RGE Pte Ltd, a resource-based enterprise with more than US$18 billion assets globally. He is currently leading the digital transformation of a variety of businesses from pulp & paper, palm oil, viscose fiber to natural gas. He has more than 18 years of industry experience in digital and technology. A computer engineering scholar from National University of Singapore, Abhishek has experience working in start-ups, medium size enterprise to global brands like Singapore Airlines and Infosys.

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Corporate Placements

HR Agency: "Sir, we have selected few candidates as per your requirements. Now how do you want their placements sir?"

M.D and CEO: "Put about 100 bricks in a closed room. Then send the candidates into the room & close the door, leave them alone & come back after a few hours and analyse the situation:-

1) Any candidates counting the bricks, Put them in Accounts deptt.

2) If they are re-counting the bricks, Put them in Auditing.

3) If they have messed up the whole room with the bricks, Put them in Premises.

4) If they are arranging the bricks in some strange order, Put them in Planning.

5) If they are throwing the bricks at each other, Put them in Operations.

6) If they are sleeping, Put them in Security.

7) If they have broken the bricks into pieces, Put them in Information Technology.

8) If they are sitting idle, Put them in Human Resources.

9) If they say they have tried different combinations yet not a single brick has been moved, Put them in Front office in Treasury.

10) If they have thinking of going out for the day, Put them in Marketing.

11) If they are worried about how to use bricks, Put them in Risk Management.

12) If they are staring out of the window, Put them in Strategic Planning.

And.......

13) If they are talking to each other and not a single brick has been touched, Congratulate them and put them in Senior Management

Leet Speak

Leet speak, also known as leet, leetspeak, leetspeek, or hakspeak, is a way of writing words by substituting numerals or special characters for some of the English letters. “Leet” derives from “elite,” which refers to hackers, who were among the first to use it and who elevated it to a sort of cult language.

Do you recognize these words? |-|4(k3r, 1337, 3D170R — respectively, they’re leet versions of hacker, leet, editor. If a computer program doesn’t know they’re a kind of code, it’s not likely to recognize the words in the midst of other text. However, a program designed to translate leet would have no problem.

Leet Speak Converter: http://www.brenz.net/services/l337Maker.asp

Leet password generator -- http://www.whatsmypassword.com/