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Preliminary Observation of Phenolic Acids on Basal Stem Rot Infected Oil Palm

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An observation was conducted in Kam Cheong Plantations Sdn Bhd, Lungmanis Fields 8 and 10, Sandakan, Sabah from October 2018 to September 2019. A biocontrol formulation consisting of phenolic acids was applied to Ganoderma *infected palms* via *trunk injection to control the basal stem rot (BSR) and reduce the oil palm yield losses. The formulation was first produced in Universiti Malaysia Sabah before being applied to the infected palms. A total of three rounds of the phenolic acids formulation were applied to 120 infected palms in Kam Cheong with two months interval each. Every infected palm was injected with 40 ml of the formulation (20 ml/injection hole) using a manual trunk injector. This was followed by monitoring and recording of the oil palm yield and disease recovery. The recovery of the infected palms was assessed based on the physical changes of the palms. Out of the 120 treated palms in the two affected areas, 68.33 per cent were still productive although infected, 13.33 per cent recovered from the infection, 9.17 per cent had dead* Ganoderma *fruiting bodies but with BSR foliar symptoms while 9.17 per cent collapsed or died after the six months' observation. The fresh fruit bunch yield increased from 1.24 to 3.14 tonnes per hectare in Field 10, an increment of about 154 per cent. However, the yield varied in Field 8 during the observation. This paper serves as a preliminary report on the benefits of phenolic acids to* Ganoderma *infected palms. More research may be necessary in the future to confirm this result especially on the effect of yield.*

Keywords: Ganoderma, *phenolic acids, biocontrol, oil palm, basal stem rot.*

Basal Stem Rot (BSR) disease of oil palm caused by *Ganoderma* spp is one of the most devastating diseases affecting oil palm production in South East Asia. Although several species were reported to cause BSR, however, *G. boninense* was reported to be the most aggressive (Idris *et al.*, 2000). *Ganoderma* infection has been hampering the production of oil palm for many years with reported losses of up to USD 500 million a year in Malaysia with an average mortality rate of 3.7 per cent (Hushiarian *et al.*, 2013). Attempts to control the disease has been taken to wider extent, including cultural practices (clean clearing, windrowing, mounding, surgery, digging trenches and sanitation), fungicide application, development of resistant variety and application of biological control (Chong *et al.*, 2017). Nonetheless, to date, no conclusive control has been reported in combating *Ganoderma*. The ineffectiveness in managing the disease may be due to several reasons

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such as the several different resting stages that pathogen has and more importantly, lack of *in situ* detection methods which can be carried out by the plantation personals. The development of the symptoms of infection is rather slow and may take several years before it is visible in mature palms. However, once these symptoms are visible, at least 50-60 per cent of the internal trunk tissues would be rotten and any remedy may be too difficult at this time.

Kam Cheong Plantations Sdn Bhd is an oil palm plantation company located in Sandakan, Sabah with about 878.76 ha planted areas across two estates; Mile 25 and LungManis. Sandakan has been pronounced as the region which is most severely affected by *Ganoderma* with about 28.16 per cent of disease incidence recorded according to the report by the MPOB-EMPA *Ganoderma* Task Force in Sabah. However, there may be more incidences which have not been reported due to the unawareness of the planters in recognising the infection at an earlier stage.

Phenolic compounds are secondary metabolites of plants. To date more than 8 000 phenolics have been found from natural sources and are classified into phenolic acids, flavonoids, stilbenes, coumarins, lignins, and tannins (Shahidi & Yeo, 2018). Phenolics play a crucial role in plants by controlling their growth as an internal physiological regulator (Cheynier *et al.*, 2013). For instance, kaempferol, apigenin, and quercetin interact with plasma membrane proteins (receptors), in which they restrict the transfer of polar auxin compounds *via* the membrane, thus affecting plant growth (Cheynier *et al.*, 2013). Phenolics in the outer part of plants shield them from fatal high-energy wavelengths by absorbing them in advance. In other words, electron-rich parts such as the π-bond of the phenolics absorb the wavelength before attacking the critical parts of the cells (Shahidi & Yeo, 2018). Phenolic acids are important in allelopathy and replanting disease incidence (Zhao *et al.*, 2015). Phenolic compounds are autotoxins of the plants in monocropping system, such as *Rehmannia glutinosa*, cucumber, and tobacco (Wu *et al.*, 2015). Some studies indicate that phenolic acids change the soil microbial community with possible influences on plant performance (Zhou *et al.*, 2012, 2014). Although there are some evidences on the roles of certain phenolic acids in oil palm against *G. boninense* (Chong *et al.*, 2012a, b), but, little is known on the effects of these phenolic acids if applied as a biocontrol of *Ganoderma* in the infected palms.

Therefore, an observation was conducted to evaluate the effectiveness of a biocontrol formulation consisting of phenolic acids from Universiti Malaysia Sabah (UMS) in controlling *Ganoderma* infection and its potential to reduce the yield losses due to the infection.

METHODOLOGY

Site selection

Kam Cheong Plantations Sdn Bhd has two estates, namely Mile 25 and LungManis in Sandakan, Sabah. Mile 25 Estate had just started its replanting programme, therefore, LungManis Estate was selected for this observation based on the age of palms (20 years old; planted in year 1999) and the high incidence of *Ganoderma*. Two fields from LungManis Estate were involved in this observation and they are Field 8 (51.37 ha) and Field 10 (62.98 ha).

Preparation of biocontrol formulation

A biocontrol formulation tested during this observation is a patented product (PI:2010004642) developed by the researchers of UMS. It is a

combination of phenolic acids (syringic; 45% and caffeic acids; 40%) with 5 per cent of inert materials. The formulation was prepared in UMS. The final volume of the formulation was in 1 litre.

Application of biocontrol formulation in field

The application of the phenolic acids formulation was done by the field workers supervised by staff from UMS and Assistant Manager of Kam Cheong. The field workers were first trained by the researchers on the application of the formulation before they were allowed to treat the palms under supervision. In brief, 120 infected palms were selected for the treatment based on their visual/disease symptoms. All the 120 palms showed the presence of either *Ganoderma* fruiting bodies, skirting or with broken fronds, presence of cavity/decay of trunk tissues and/or unopened spear. The selected palms were then drilled with two holes to a depth of about 30 cm on their trunks (*Figure 1a*). The holes were about 1 to 1.5 m high from the ground and opposite to each other. Each palm was injected with 40 ml of the phenolic acids formulation (20 ml for each hole) using a manual trunk injector (*Figure 1b*). The treatment was repeated every two months for three rounds.

Data collection and statistical analysis

The treated palms were observed throughout the duration and the appearance/disappearance of the visual/disease symptoms as mentioned earlier was recorded. A palm is considered recovered if all the visual/disease symptoms are not present including other promising symptoms of recovery such as formation of new roots in the cavity area. The fresh fruit bunch (FFB) yield for Fields 8 and 10 were also recorded monthly from January 2019 (before the application) till July 2019 (after application) for comparison of the effectiveness of the treatment. The yield data was analysed using one-way ANOVA and post-hoc (Tukey) test for the significance ($P<0.05$).

RESULTS AND DISCUSSION

Although the observation was conducted for a duration of about a year from October 2018 till September 2019, however, the first treatment was only started as early as February 2019. Some preparation works including formulating the phenolic acids formulation; co-ordinating and training the workers took place from October 2018-January 2019. The different categories of palms after treatment with biocontrol formulation are shown in *Figure 2*. Out of the 120 palms which were treated using

Figure 1 a) Drilling holes on the trunk for about 30 cm in depth and 1-1.5 m high from the ground for the application of treatment, and b) injection of phenolic acids formulation using a manual trunk injector

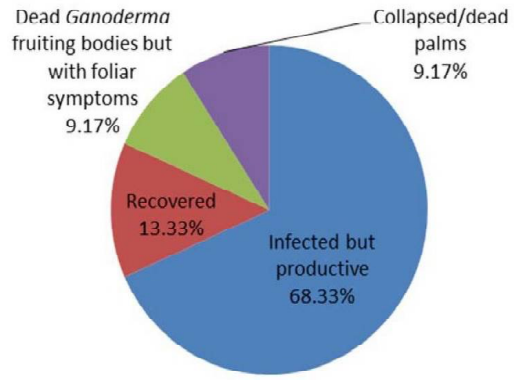

Figure 2 The different categories of palms after three rounds of treatment with phenolic acids formulation

phenolic acids formulation, 82 palms (68.33%) remained infected with visual/disease symptoms. However, the palms were still productive and bearing fruits. On the other hand, 16 palms (13.33%) were recorded as recovered from the disease, without the presence of any visible/disease symptoms such as *Ganoderma* fruiting bodies, skirting/broken fronds, cavity/decay of trunk tissues and/or unopened spear. In addition to this, 11 (9.17%) of the treated palms also with their *Ganoderma* fruiting bodies were found dead or dried off but still with BSR foliar symptoms. This is another indication of the effectiveness of the treatment. However, 11 palms (9.17%) collapsed or died during the period of observation. The different visual/disease symptoms recorded before and after the treatment are illustrated in *Figures 3* and *4*.

In an earlier report, Jee and Chong (2015) demonstrated the effect of phenolic acids combination in controlling *Ganoderma* in infected palms. The combination of syringic, caffeic and 4-hydroxybenzoic acids was reported to suppress the colonisation of *Ganoderma* in infected oil palm trees. The two highest tested concentrations of 0.4 g and 0.3 g active ingredient suppressed the fungi best with the least amount of fungal ergosterol/ biomass reflected from the analysis. However, lower concentrations were not as effective as commercial hexaconazole (Jee & Chong, 2015). In a separate report, Chong *et al*. (2009a) also demonstrated the same phenolic acids to be toxic to *G. boninense* while the synergy effect of the combinations of them against this pathogen were also reported to have higher toxicity effect against the pathogen (Chong *et al.*,2009b). In this observation, the physical changes of the infected palms when applied with the phenolic acids may possibly be explained with findings from the previous research. The toxicity from the combination of these phenolic acids may kill the *Ganoderma* leaving 13.33 per cent of the palms, in this treated group, recovering without foliar symptoms, while another 9.17 per cent with dead *Ganoderma* fruiting bodies but with foliar symptoms. Nonetheless, in this observation the phenolic acids formulation was applied to all palms infected by *Ganoderma* at the beginning of the observation without considering the stage of the infection. The difficulty in managing this disease is due to not exhibiting any external symptoms on mature palms until advanced stage. When it comes to this stage, the infected trees may not be able to respond to any treatment given (Bivi *et al.*, 2016), which may explain the 9.17 per cent of the dead or collapsed palms though they were treated by the formulation. Most of the palms (68.33%) were still productive despite being infected and this is also in accordance to Idris *et al.*, (2004) who suggested infected palms left untreated will not survive after a certain period of time.

Besides monitoring the development of the disease of the palms in the study area, the yields from the two fields were also recorded and a

Figure 3 Some of the visual/disease symptoms recorded before phenolic acids formulation treatment in LungManis Estate of Kam Cheong Plantations Sdn Bhd. a) Light skirting/broken fronds, b) severe skirting and broken fronds, c) the presence of Ganoderma *fruiting bodies (arrowed) and d) hollow due to cavity (in circle)*

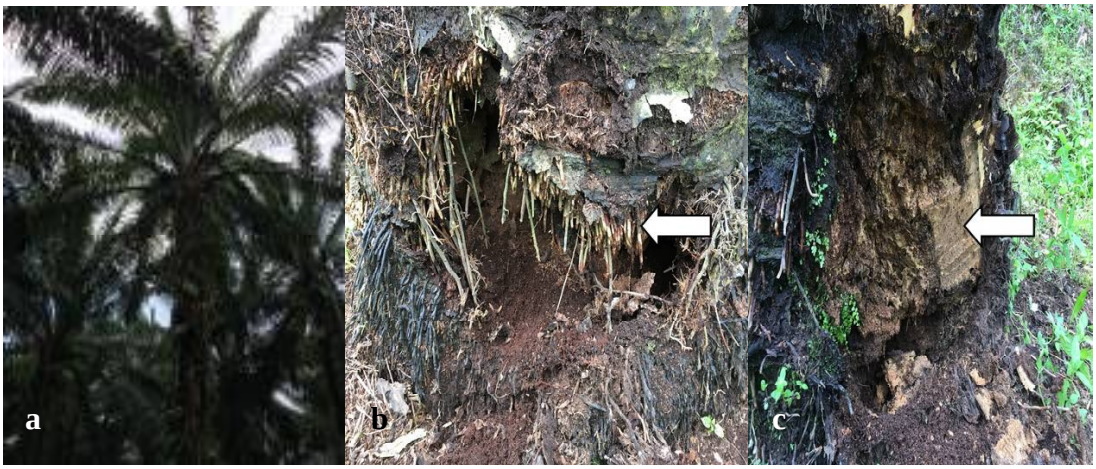

Figure 4 Some of the visual/disease symptoms recorded after phenolic acids formulation treatment in LungManis Estate of Kam Cheong Plantations Sdn Bhd. a) Palm with no skirting or broken fronds after pruning, b) new roots found growing out from the cavity area (arrowed), and c) no more further decaying tissues were found when the dead tissues were removed exposing the white/healthy tissues (arrowed)

comparison of yield is shown in *Table 1*. Although the number of palms which were treated by the phenolic acids formulation may not be many within the two fields, but, a positive record of yield increment was found in Field 10. The yield has been increasing from month to month after the first application of phenolic acids formulation in January 2019. However, a sharp fall in yield was recorded in April and June in the same field. This may probably be

TABLE 1
FRESH FRUIT BUNCH IN TONNES/HECTARE RECORDED IN FIELDS 8 AND 10 OF LUNGMANIS ESTATE OF KAM CHEONG PLANTATIONS SDN BHD FROM JANUARY TILL JULY 2019 DURING THE TREATMENT OF PHENOLIC ACIDS FORMULATION

Month of 2019	*Yield (tonnes/ ha) Field 8*	*Yield (tonnes/ ha) Field 10*	*Remark*
January	1.98[a]	1.234[e]	Before phenolic acids formulation treatment
February	2.20[b]	1.94[f]	Phenolic acids formulation treatment-first round
March	1.72[c]	1.83[g]	Phenolic acids formulation treatment- second round
April	0.52[d]	0.59[h]	
May	1.75[c]	2.10[f]	Phenolic acids formulation treatment-third round
June	2.00[a]	0.56[h]	
July	1.85[a]	3.14[i]	

Statistical analysis with two-way ANOVA and post-hoc (Tukey) test. Data denoted with same letters are not significantly different ($p>0.05$)

due to some external factors such as lack of manpower in harvesting fruits and low rainfall in the two months. The final recorded yield was in July with 3.14 tonnes per hectare and it was an increment of about 154 per cent compared to January 2019 (without phenolic acids formulation) application. However, the trend of yield was not similar in Field 8, where there is no clear increment as shown in Field 10. The yield of FFB in Field 8 varied from as low as 0.52 tonnes per hectare in April, even lower than before the application of phenolic acids formulation in January (1.98 tonnes/ hectare) to the highest of 2.2 tonnes per hectare in February.

Although there is very little information on the roles of phenolic acids on the yield and growth of tropical crops especially oil palm, however, report on caffeic acid in faba bean may help us to understand the roles of the current formulation towards the increment of oil palm yield. The phenolic acids formulation used during this observation contained mainly syringic and caffeic acids as its active ingredients. Caffeic acid has been reported to increase growth of faba bean plant. At 20 ppm, caffeic acid had significant increase in the dry weight of the shoot of faba bean and seemed to have promotive effect on total photosynthetic pigments in fresh leaf tissues. Caffeic acid of up to 30 ppm was also reported to increase the total free amino acids thus contributing to growth, photosynthetic pigments and yield of the bean (El-Awadi *et al.*, 2017). To date, there is no specific report on the role of syringic acid to oil palm yield and growth. Nonetheless, phenolic compounds are an important class of plant secondary metabolites which play crucial physiological roles throughout the plant life cycle. Phenolics are produced under optimal and suboptimal conditions in plants and play key roles in developmental processes like cell division, hormonal regulation, photosynthetic activity, nutrient mineralisation and reproduction. Plants exhibit increased synthesis of polyphenols such as phenolic acids and flavonoids under abiotic stress conditions, helping the plant to cope with environmental constraints (Sharma *et al.*, 2019). Therefore, the application of the phenolic acids formulation exogenously during this observation may have assisted the palms to overcome the stress from

the *Ganoderma* infection, thus, indirectly improving the yield and growth of the affected palms.

CONCLUSION

The application of phenolic acids formulation may suppress the progression of BSR in the infected palms. This can be observed from the reduction of visible symptoms and signs of recovery in the infected palms. The yield increase in Field 10 may be in relation to the physiological recovery of the palms and possible enhancing effects from the phenolic acids. Although the yield increment was not consistent in Field 8, however, increase in FFB was also recorded. If this observation can be further extended for a longer duration with more number of palms involved, a clearer trend on the palms' recovery and increase in yield may be more obvious. This paper serves as a preliminary report on the benefits of phenolic acids to *Ganoderma* infected palms. More research may be necessary in the future to confirm this result especially on the effect of yield.

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If you cry because the sun has gone out of your life, your tears will prevent you from seeing the stars

Rabindranath Tagore