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# COMPARING SEVERAL COMBINATION OF CONTROL MEASURES IN MANAGING THE COCOA BLACK POD DISEASE IN MALAYSIA

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**ABSTRACT** - *Black pod or* Phytophthora *pod rot is the most economically important and widespread disease of cocoa in Malaysia. It is vital to study the best combination of control measures in managing the cocoa black pod disease in Malaysia. Three important control measures to be considered in the study were pruning, phytosanitary of black pod removal and fungicide application. The study plot in the Cocoa Research and Development Center Madai, Sabah was laid in the randomized completely block design with four treatments and three replications in each treatment. Among the treatments applied in the study plot are treatment 1 (combination between pruning and phytosanitary of black pod removal), treatment 2 (combination between pruning, fungicide application and phytosanitary of black pod removal), treatment 3 (combination between fungicide application and phytosanitary of black pod removal) and treatment 4 (control). The results show that the weekly black pod incidence was varied significantly by the control measures taken in controlling the disease with integrated control between pruning, fungicide application and phytosanitary of black pod removal recorded the lowest black pod incidence in treatment 2 and followed by application of pruning and phytosanitary of black pod removal in treatment 1. The application of fungicide and phytosanitary of black pod removal in treatment 3 has less effective compared to integrated control measures in treatment 2. As a conclusion, the combination between pruning, fungicide application and phytosanitary of black pod removal was effectively controlled the black pod incidence and will be recommended to the cocoa growers*.

***Key words:*** Cocoa black pod, *Phytophthora*, phytosanitary, fungicide, pruning

## INTRODUCTION

Cocoa black pod that caused by *Phytophthora* spesies has made the cocoa farmers around the world including Malaysia to suffer economic losses that exceed $400 million worldwide (ICCO, 2019). Among the *Phytophthora* sp. that attacked the cocoa, *Phytophthora palmivora* is the most widely distributed in the world and it caused global yield loss of 20-30% and tree deaths of 10% annually (ICCO, 2019).

Farmers always look for the best alternative to manage the problem of cocoa black pod disease to minimize the losses. There are several approaches to control the disease ranged from cultural practices, resistance breeding, biological control and chemical application (Vos *et al.*, 2003). For long term solution, farmers can opt for planting the resistance clones as it provides the most economical, environmentally friendly and effective control method but subjected to available of the resistance clones (Iwaro and Singh, 2004). For short term solution, the control measures recommended to cocoa farmers in Malaysia are cultural practice and chemical control (Lee *et al.*, 2013). The cultural involved regularly pruning the canopy of the cocoa tree to increase sunlight and air flow around the cocoa trees and remove all infected cocoa black pods from the cocoa field. It makes the fungi difficult to spread through the crop (Luseni and Kroma, 2012). Good sanitation and harvesting practices of regularly harvest ripe and healthy pods will prevent post-harvest losses due to the cocoa black pod disease (Acebo-Guerrero *et al.*, 2012; Vos *et al.*, 2003). In chemical control, Metalaxyl, a systematic fungicide is recommended to control the disease while copper based fungicides are applied to prevent infection (Acebo-Guerrero *et al.*, 2012). Normally, biweekly systematic sprayings are carried out prior to the rainy seasons (Lee *et al.*, 2013).

However, the effectiveness management of cocoa black pod disease needs an understanding of the agronomics of the crop in orders to allow one to develop effective, integrated disease control methods. By applying single approach might not give the best results in controlling the cocoa black pod disease, it is better to combine several control methods or better known as integrated disease management such as fungicide and cultural practice to be effective in eliminating the sources of primary inoculums of the *P. palmivora* (Guest, 2007). However, no attempt has been so far made in Malaysia to develop effective integrated disease management strategies for this disease considering the economic value. Considering the importance of black pod disease, studies were undertaken to develop the effective and economically integrated disease management practices.

## MATERIALS AND METHODS

### *Study Sites and Experimental Design*

The study is conducted in the cocoa mature areas in Field 5B located at the Cocoa Research and Development Centre (CRDC), Madai, Sabah with the coordinates of latitude and longitude as 4$^o$ 47' 10" N and 117o 57' 54" E. The Field 5B with the size of 1 hectare has 1,111 trees and planted with cocoa clone of PBC 123.

There were four treatments with 90 trees / treatment that laid out in Randomized Completely Block Design (RCBD) with three replications in Field 5B. Treatments were the combination of three control measures of pruning, phytosanitary of black pod removal and fungicide application which is given as follows:

**Treatment 1:** Combination between pruning and phytosanitary of black pod removal.

**Treatment 2:** Combination between pruning, fungicide application and phytosanitary of black pod removal.

**Treatment 3:** Combination between fungicide application and phytosanitary of black pod removal.

**Treatment 4:** Control without any treatment of pruning, fungicide application and no phytosanitary of black pod removal.

The condition of the plots received four different treatments were shown in Figures 1 to 4. The fungicide of Halex Copper-Oxy 84 with the active ingredient of copper oxychloride was used and sprayed every two weeks meanwhile the pruning is carried out every month to open up the cocoa tree canopy for more light to penetrate. The treatment plot was surrounded by two rows of cocoa trees as phytosanitary barrier to prevent chemical treatments and pathogen spread from neighbouring plots.

*Figure 1: The cocoa plot applied with Treatment 1*

*Figure 2: The cocoa plot applied with Treatment 2*

*Figure 3: The cocoa plot applied with Treatment 3*

*Figure 4: The cocoa plot applied with Treatment 4*

***Sampling Method***

In this study, the simple random sampling method was used to select the sampling units which are the individual cocoa trees in the treatment plot. Ten trees per treatment in each plot were randomly selected. The selected ten trees were observed weekly from February 2015 to December 2016 (89 weeks). In each tree, two stages of pod development were assessed, namely the young pods (less than three months old pods) and mature pods (more than three months old). Individual tree observation was made with weekly counting of the healthy and black pod of two different stages. After counting data collection, sanitary harvest is practiced in the treatments where the diseased pods and damaged pods were removed except the control plot in treatment 4.

The cocoa black pod disease incidence is measured from the cocoa pods observed from the sampling unit that is categorized into healthy and diseased. The calculation method for the weekly black pod rate in treatment *n* (BPRTRT*n*) is adapted from the formula used in Ndoumbe-Nkeng *et al,* (2004) and Ngoh Dooh *et al,* (2015) as follows:

$BPTRTn_{ijk}$ calculated at week *i* on tree *j* in replication *k* in treatment *n* is as follows:

$$BPTRTn_{ijk} = (BP_{ijk}) / (YP_{ijk} + AP_{ijk}) \qquad (1)$$

$i = 1, 2, \ldots, 89, j = 1, 2, \ldots, 10$ and $k = 1, 2, 3, 4$.

where,

$BP_{ijk}$ is the number of black pods observed at week *i* over each selected tree *j* in replication *k*,

$YP_{ijk}$ is the number of young pods observed at week *i* over each selected tree *j* in replication *k*, and

$AP_{ijk}$ is the number of mature pods observed at week *i* over each selected tree *j* in replication *k*.

***Statistical Analysis***

In this study, two-way Analysis of Variance (ANOVA) test was used to study the effect of the treatment and cocoa development stage on the mean weekly cocoa black pod disease incidence. The Duncan's Multiple-Range Test (DMRT) is used to make the comparison of the mean weekly cocoa black pod disease incidence between the treatments or the cocoa pod development stages. Prior to two-way Analysis of Variance (ANOVA) test was used, there were two assumptions that need to be checked and confirmed, the distribution of data (i.e. mean weekly cocoa black pod disease incidence) is normally distributed and all the treatments have equal variance. The Shapiro-Wilk test was used to test the normality assumption and originally restricted for sample size of less than 50 (Shapiro and Wilk, 1965). The Levene's test was used to test the homogeneity of variances by verified the equal variances assumption among *k* samples (Levene, 1960).

## RESULTS AND DISCUSSION

### *Trend of Cocoa Black Pod Incidence at Four Treatments*

The weekly cocoa black pod disease incidence trend showed that the black pod incidence in 89 weeks gave the treatments 3 and 4 fluctuated higher compared to treatments 1 and 2 as shown in Figure 5. The graph in Figure 5 showed treatments 1 and 2 have an effect in reducing the black pod incidence compared to treatments 3 and 4. The black pod incidence in treatment 1 was fluctuated below 11.80% meanwhile treatment 2 recorded black pod incidence fluctuated consistently below 9.40%. The effect of pruning in treatments 1 and 2 has shown positive sign in reducing the cocoa black pod disease infection among the cocoa trees but the addition of fungicide application able to reduced the incidence in treatment 2. However, the treatment 3 that only used fungicide and phytosanitary of diseased pod removal recorded black pod incidence below 24.80%. The control in treatment 4 still recorded the highest incidence of 32.30% at week 80 and has large variation in incidence during week 70 onwards.

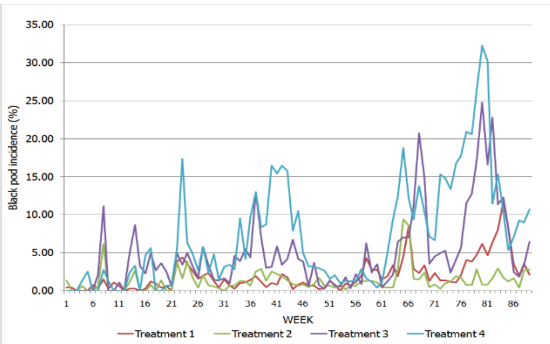


*Figure 5: Weekly cocoa black pod incidence from February 2015 to December 2016 for four treatments*

### *Effect of Treatments and Pod Development Stages on Cocoa Black Pod Incidence*

Table 1 shows the results of the Shapiro-Wilk test on the untransformed mean proportion weekly cocoa black pod disease incidence data gave the p-value equal to 0.0600 that null hypothesis of normally distributed was not rejected at 5% significant level. Table 2 shows the result of the Levene's test on the untransformed mean proportion weekly cocoa black pod disease incidence data gave the p-value equal to 0.2488 that the null hypothesis of equal variances can't be rejected at 5% significant level. The statistical test showed the untransformed data fulfilled the ANOVA test's assumptions on data normality and equal variances.

Table 1: Normality test on proportion weekly cocoa black pod incidence

| ***Statistical Test*** | ***Statistic*** | ***p-value*** |
|---|---|---|
| Shapiro-Wilk test | 0.921 | 0.0600 |

Table 2: Homogeneity of variances test on proportion weekly cocoa black pod incidence

| ***Statistical Test*** | ***Statistic*** | ***p-value*** |
|---|---|---|
| Levene's test | 1.490 | 0.2488 |

Table 3 shows the result of the two-way ANOVA test indicated that the effect of the treatments on the untransformed data with F-value equal to 31.51 was significant at 5% level. However, the effect of the pod development stages and interaction between treatments and pod development stages showed no significant different at 5% level.

Table 3: Analysis of Variance (ANOVA) on proportion weekly cocoa black pod incidence

| ***Source*** | ***df*** | ***Sum of Squares*** | ***Mean Square*** | ***F*** | ***p-value*** |
|---|---|---|---|---|---|
| Pod Development Stages (A) | 1 | 0.000091 | 0.000091 | 0.45 | 0.5107 |
| Treatment (B) | 3 | 0.019056 | 0.006352 | 31.51 | <0.0001 |
| Interaction between A and B | 3 | 0.001045 | 0.000348 | 1.73 | 0.2014 |
| Error | 16 | 0.003225 | 0.000202 | | |
| Total | 23 | 0.023418 | | | |

Note: df – degree of freedom.

The results of the Duncan's Multiple-Range Test (DMRT) in Table 4 shows the untransformed data in treatments 1, 2 and 3 were significantly lower than treatment 4 at 5% level. Meanwhile, treatments 1 and 2 were significantly lower than treatment 3 at 5% level. However, there was no significant difference between the treatments 1 and 2 at 5% level. As treatments 1 and 2 involved pruning as one of the control measures compared to treatment 3. Result showed applying fungicide or chemical control without pruning was not effective as compared to pruning alone or combination between pruning and fungicide. Peter and Chandramohanan (2014) has proved that the integration of control measures between the fungicide application and cultural practices has effective controlling to the cocoa black pod disease incidence when the incidence was high and used of cultural practices for less incidence in India. This practice also helps reduce the field humidity as high humidity is favorable for the pathogen to infect the pods (Akrofi, 2000).

Table 4: Comparing mean proportion weekly cocoa black pod incidence each treatment

| ***Treatment*** | ***Mean proportion weekly cocoa black pod incidence[a]*** |
|---|---|
| 1 | 0.0247c |
| 2 | 0.0149c |
| 3 | 0.0569b |
| 4 | 0.0865a |

Note: [a] Values with the same letter in a column are not significantly different (p-value > 0.05) according to the Duncan's Multiple-Range Test (DMRT).

***Estimating Losses from Cocoa Black Pod Disease Incidence***

Table 5 shows the estimation losses from cocoa dried bean losses and economic losses in each treatment sampled from 30 trees from February 2015 till December 2016. The cocoa dried bean losses from the cocoa black pod disease incidence was estimated from the pod index (PI) that referred to number of pods needed to get 1 kilogram (kg) of dried cocoa beans and differ according to clones as reported in Haya *et al* (2012). For example, the pod index for clone PBC 123 used in this study was 23 (Haya *et al*, 2012). Meanwhile the estimation of economic losses from cocoa dried bean losses was based on the price of cocoa dried beans per kilogram for example RM8.00 per kilogram at monitoring time of grade two of Standard Malaysia Cocoa (SMC 2) at Tawau purchasing center which near to the study plot.

Based on the Table 5, the estimated dried bean losses in treatment 1 was 37.49 kg and the economic losses was RM317.46. As for treatment 2, the estimated dried bean losses was 18.47 kg and the economic losses was RM156.04. The estimated dried bean losses in treatment 3 was 56.25 kg and the economic losses was RM482.02. As for treatment 4 in Table 5, the estimated dried bean losses was 97.14 kg and the economic losses was RM842.11. The estimation losses showed treatment 2 with combination of three control measures (pruning, fungicide and pytosanitary of diseased pod removal) has the lowest economic losses followed by the treatment 1 with combination of two control measures (pruning and pytosanitary of diseased pod removal) then treatment 3 with combination of two control measures (fungicide and pytosanitary of diseased pod removal). Treatment 4 which was control plot without any control measure having the highest losses.

Table 5: Estimation of the losses in four treatments for 89 weeks

| ***Treat ment*** | ***Total pods*** | ***Disease pods*** | ***Dried bean losses (kg)*** | ***Economic losses (RM)*** |
|---|---|---|---|---|
| 1 | 40,693 | 863 | 37.49 | 317.46 |
| 2 | 33,133 | 426 | 18.47 | 156.04 |
| 3 | 25,224 | 1294 | 56.25 | 482.02 |
| 4 | 24,783 | 2234 | 97.14 | 842.11 |

## CONCLUSIONS

The results of the study has showed that the integrated treatments of pruning, fungicide application and phytosanitary of black pod removal gave the best solution to the cocoa farmers in managing the cocoa black pod problem with the lowest incidence observed and also economic losses. Followed by the integrated treatments of pruning and phytosanitary of black pod removal as second best solution for cocoa farmers who only prefer to go for organic farming without using chemical in their farms. However, application of fungicide and phytosanitary of black pod removal without pruning proved to be not effective as the disease incidence or economic losses seen to be higher compared to the integrated treatment with pruning. Therefore, the cocoa farmers are advised to practice pruning and fungicide application in their farm as one of the best solution in managing the cocoa black pod disease problem.

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