MONITORING COCOA BLACK POD DISEASE INCIDENCE WITH EXCEL TOOL

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ABSTRACT – *This paper is to share knowledge on how to utilise the Pivot Table in Microsoft Excel in monitoring the cocoa black pod disease (CBPD) incidence and managing the disease. The cocoa black pod disease was one of the major disease in cocoa planting around the world and caused major losses to the growers. Although cocoa growers have taught to manage the CBPD problem with integrated disease management involved culture practices and chemical, they need a proper monitoring system to guide them when is the right time to take actions especially on chemical. Introducing the data-based monitoring on every individual trees per unit area for the CBPD using Pivot Table will solve their problem. A pivot table is an interactive table that allows user to sort and display data based on filters without changing the source data as display and source data are separate. In this study, a Pivot Table was applied on sub-plot 1 approximated to 1 hectare planted with mix clones located in the Cocoa Research and Development Center (CRDC) Kota Samarahan to monitor the CBPD incidence. The CBPD incidence data was collected weekly while the weather data was collected hourly, then summarised using the Pivot Table to give useful information for growers to make decision in controlling the CBPD. The plot maps relative to the CBPD incidence were also being suggested to the cocoa growers* to *understand the performance of individual cocoa trees against the CBPD in long term.*

Key words: Cocoa, cocoa black pod disease, decision making, excel, pivot table

INTRODUCTION

Cocoa black pod disease casued by the fungus *Phytophthora* spp. has affected cocoa productivity in major producing countries including Malaysia with pod loss around 20 to 30% annually (Acebo-Guerrero *et al.*, 2012). There are few fungal species identified to be responsible for the black pod disease, for example *Phytophthora palmivora*, *Phytophthora megakarya* and *Phytophthora capsici* but the major *Phytophthora* fungus found in Asia including Malaysia was *Phytophthora palmivora* species (Despréaux, 2004, International Cocoa Organisation, 2015). *Phytopthora palmivora* has direct impact on production as its infection reduced the harvest of cocoa acceptable beans besides causing canker on trunk and branch of cocoa tree that will eventually kill the tree (International Cocoa Organisation, 2015). The cocoa pod disease symptoms appear within 3 to 4 days after infection has occurred and spread over the entire pod within two weeks (Thorold, 1975).

Cocoa growers have been taught to tackle the cocoa black pod disease problem with integrated disease management that involved culture practices and chemical. The cultural practices in managing the cocoa black pod disease 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 (Luseni and Kroma, 2012). Common type of chemicals used are copper compounds (copper oxide or copper sulphate) either singly or in combination with metalaxyl (Vos *et al.*, 2003). Common practice among cocoa growers was at three or four-week intervals (Acebo-Guerrero *et al.*, 2012). However, the effectiveness of chemical or fungicide application relied on right timing to take action in order to reduce the losses and achieving better cost-benefit ratio. Therefore, data-based monitoring on every individual trees per unit area for the cocoa black pod disease become critical to assist cocoa growers to identify the right time to control the disease.

Lee and Azhar (2006) have highlighted the Accountable Management System should be introduced in cocoa farm as a function of "traceability" and "responsibility" to ensure every cocoa tree in the fields able to contribute collectively to the overall productivity or production per unit area. The introduction of the Industrial Revolution 4.0 in the agriculture sector, data management have become the key element in modern agriculture and it is growing exponentially to assist growers with critical decision-making (Veronica and Francisco, 2020). However, a series of data collection on the disease without retrieving something coherent and valuable information may caused the data not useful but just numbers. To make sense of data, proper visualizations are key and this can be easily visualised with Microsoft Excel. A pivot table is just another way of viewing the data in Microsoft Excel by restructuring the raw numbers in a different way to give more legible and valuable information. It is a tool with ability to collect the summary of a specific data set in a compressed technique and consolidating a large quantity of data that is contained in Microsoft Excel (Association of Business Training, 2013). Besides, the tool allowed the user make a faster organization and drawing of conclusions from data being collected. In this paper, we will share how to utilise the Pivot Tables in Microsoft Excel as data-based monitoring on the cocoa black pod disease (CBPD) incidence to assist cocoa growers to identify the right time to control the disease.

MATERIALS AND METHODS

Description of the Experimental Plot

The experiment was conducted on sub-plot 1 approximated to 1 hectare planted with mix clones located in the Cocoa Research and Development Center (CRDC) Kota Samarahan, Sarawak, Malaysia. In this study, 100 cocoa mature trees from sub-plot 1 was selected and divided into 13 groups for easy management on cocoa black pod disease as shown in Figure 1.

Derived Variables and measurement

The CBPD incidence data was collected weekly from December 2019 to April 2021 and the assessment of the cocoa black pod disease rate was based on monitoring the mature and ripe pods adapted from Nkeng *et al.* (2017) and Ling *et al.* (2019) as follows:

The weekly cocoa black pod disease rate (W) on tree j at week i was calculated as

$$W_{ij} = \frac{(BP_{ij} \times 100)}{(MP_{ij} + RP_{ij})}$$

where BP_{ij} is the number of mature and ripe black pods observed over tree j in week i, MP_{ij} is the number of mature pods over tree j in week i and RP_i is the number of healthy ripe pods over tree j in week i.

Meanwhile the cumulative cocoa black pod disease rate (Y) on tree j at week i was calculated as

$$Y_{ij} = \frac{(\sum_{i=1}^{n} BP_{ij} \times 100)}{(MP_N + \sum_{i=1}^{N} (BP_{ij} + RP_{ij}))}$$

where n is the number of the calculation week, N is the total number of weeks' observations, BP_{ij} is the number of mature and ripe black pods observed over tree j in week i, MP_N is the number of mature pods in the final week of observations and RP_{ij} is the number of healthy ripe pods over tree j in week i.

The daily weather variables (rainfall, relative humidity and temperature) were recorded using WatchDog data loggers (1000 Series Micro Station, Spectrum Technologies, Aurora, IL, USA) from December 2019 to April 2021.

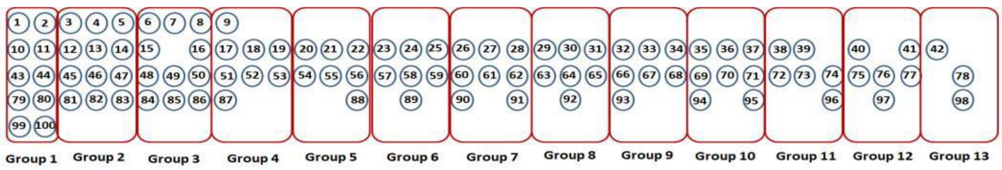

Figure 1. Study plot layout of 100 cocoa trees grouped by 13 groups

Creating Pivot Table

The Pivot Table in the Microsoft Excel was created on the data collected and the general steps involved are as followed:

a. Select range of data to create the Pivot Table
b. Create Pivot Table: Insert >> Tables >> Pivot Table
c. Select New Worksheet or Existing Worksheet depending on where the Pivot Table to appear
d. Once a blank Pivot Table and Pivot Table Field List are displayed,
    i. Drag the fields with the data we want to display in rows / column to the area on the Pivot Table diagram that labeled as the Row / Column Labels box.
    ii. Drag the fields that contain the data you want to summarize to the area that labeled Values box.
    iii. Click the field that we want to change its summary value, then select value field settings followed by choosing the type calculation that you want to use to summarize data from selected field

Statistical Analysis

Pearson correlation was used to measure the strength of the relationship between weekly CBPD incidence and the climate data and determine the potential climate variables that causing the CBPD incidence increased.

The Moran's *I* test was used to evaluate the degree of spatial autocorrelation between neighbouring trees bearing diseased pods. The test utilised neighbourhood category by considering of the nearest neighbours in rows or columns (Reynolds and Madden, 1988). The statistics used to calculate the degree of spatial autocorrelation is as follows:

$$I = \frac{\frac{1}{N_h}\sum_{i=1}^{Nh}(Z_i - \bar{Z})(Z_{i+h} - \bar{Z})}{\frac{1}{n}\sum_{i=1}^{n}(Z_i - \bar{Z})^2}$$

where N_h is the number of pairs (i, $i + h$), Z_i is the cumulative cocoa black pod disease rate at the i^{th} position, Z_{i+h} is the observation at the position separated by h units from i and n is the number of points in the network.

The value of spatial autocorrelation, *I* was tested with *Z*-test by comparing the standardised *I* statistic to the quantiles of the standard normal distribution, φ^{-1} where the null hypothesis of data is randomly disbursed was rejected at the 5% significance limit if expression was verified:

$$Z = \frac{I - E(I)}{\sqrt{Var(I)}} \geq \varphi^{-1}{}_{0.95}$$

where *E(I)* is the mean (or expected value) of *I* and *Var(I)* is its variance. The calculation of *E(I)* and *Var(I)* are explained in Ristaino and Gumpertz (2000).

The data management including data entry, organising, summarising with numerical and graphical, analysing and making decision were carried out with Micosoft Excel 2016.

RESULTS AND DISCUSSIONS

When the growers planned to monitor which month may caused high CBPD incidence, he can drag fields of "Year" and "Month" to the row label box in the Pivot Table and drag the CBPD incidence into Values Box and changed the values to average. This was followed by selecting bar graph from the Pivot Chart to display the status of CBPD incidence by months. Figure 2 gave a overview of the CBPD incidence status of their plot to the growers and which month may caused them more yield loss. The trend of CBPD incidence varied from December 2019 to July 2021 with monthly incidence could reached higher (> 15%) during January 2020 and incidence consistently maintain at 10% from February 2020 to May 2020 before droping to below 10% during June 2020 to December 2020. However, the increased trend of above 10% was observed in January 2021 and gradually drop to below 10% till April 2021.

The growers may need to know which group of cocoa trees that contributed to higher CBPD incidence. So, he can drag “Group” field to the row label box and “Year” field to the column label box in the Pivot Table. This was followed by selecting bar graph from the Pivot Chart to display the status of CBPD incidence by groups. Then, he can use the “Insert Slicer” to narrow down the focus to selected month and year to guide the grower faster and easier to filter data visually. Since CBPD incidence was observed high in January 2020 (see Figure 2), the grower can click 2020 in field “Year” and 01 in field “Month” at the “Insect Slicer”. Figures 3 gave the display of CBPD incidence focusing on January 2020 with higher disease rate. Results showed Groups 12 and 13 recorded CBPD incidence above 30%. This will lead to the grower to focus on both groups and took immediate actions.

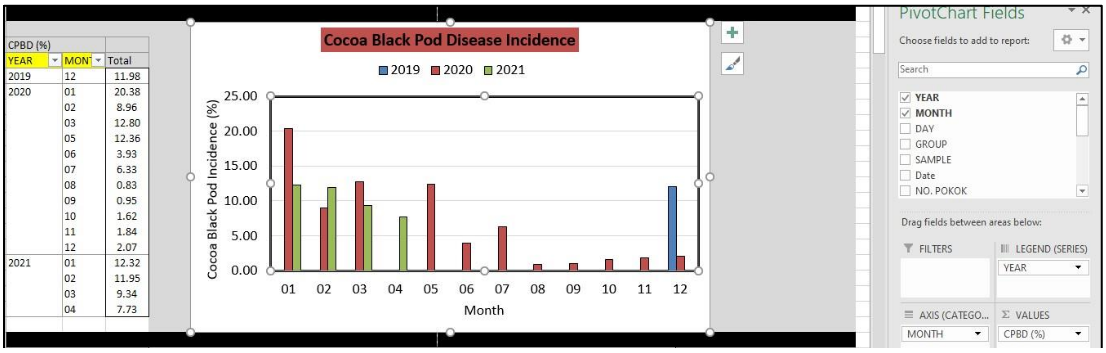

Figure 2. Monitoring monthly CBPD incidence filtering by year

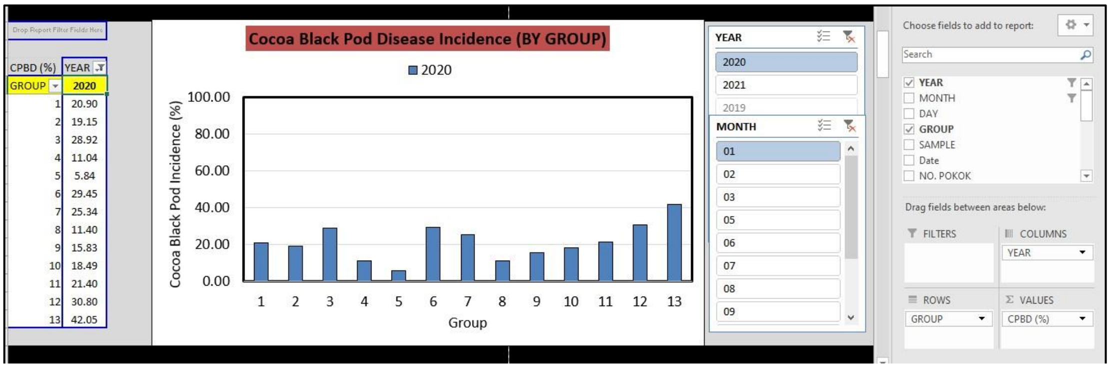

Figure 3. Monitoring CBPD incidence based on cocoa trees grouping focused on January 2020

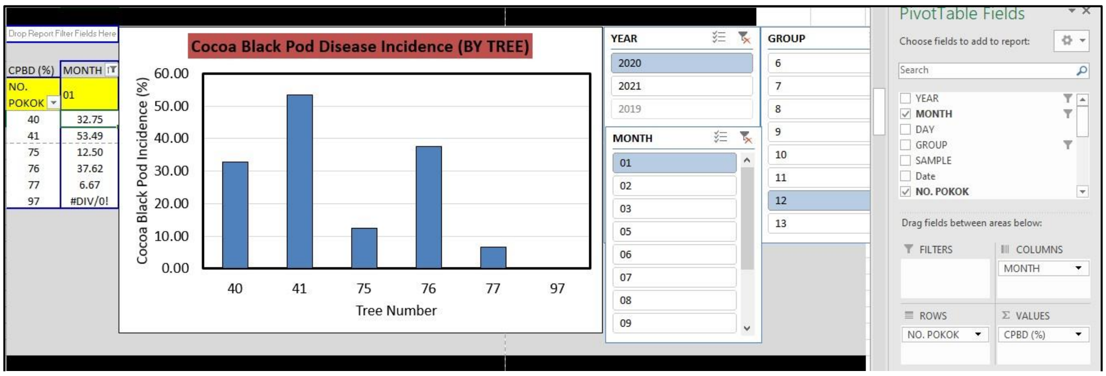

Figure 4. Monitoring CBPD incidence based on individual cocoa trees focused on Group 13 in January 2020

In addition, action can be taken on targeted individual cocoa trees in Group that gave higher disease incidence. In this case, grower can use Pivot Table to identify the individual cocoa trees in group 13 by dragging "Tree Number" field to the row label box and "Month" field to the column label box. This was followed by selecting bar graph from the Pivot Chart to display the status of CBPD incidence by trees. Then, he can use the "Insert Slicer" to narrow down the focus to selected group, month and year. Figures 4 gave the display of CBPD incidence focusing on Group 13 in January 2020 with higher disease rate of 42.05%. Results showed tree number 40, 41 and 76 recorded higher CBPD incidence with 32.75%, 53.49% and 37.62%. Control measures can be initiated on those trees immediately by applying fungicides.

The fluctuation of CBPD incidence in subplot 1, CRDC Kota Samarahan was correlated with the climate variables as showed in Table 1. Relative humidity at lag 1 day and mean temperature at lag 3 days gave significant correlation at 5% level. Strong correlation of both climate variables also agreed with results found in Cilas *et al.* (2004) and Joseph *et al.* (2009). However, the positive direction of correlation between CBPD incidence and mean temperature at lag 3 days was contrast with the logic of decreasing temperature will increase the CBPD incidence. In this case, the growers can observed the changing in relative humidity at lag 1 day that may trigger the CBPD to spread.

The progress of cumulative CBPD incidence in subplot 1, CRDC Kota Samarahan starts out at a low level and increased dramatically to reach 20% at week 15 (Figure 5). But later, the cumulative CBPD incidence gradually increased to 25% at week 44. Then, increased faster from week 45 till 57 to reach almost 35% of cumulative CBPD incidence. This trend of disease progress was following the polycyclic model which also known as sigmoid shaped curve where the model starts out exponentially then the slope decreases and approaches zero over time. This was in agreement with Cilas *et al.* (2004) who reported the CBPD has multiple cycle of infection during the epidemic which is categorized as a polycyclic disease cycle.

Table 1. Correlation CBPD incidence with climate variables in subplot 1, CRDC Kota Samarahan from December 2019 to April 2021

Parameters	Pearson Correlation	P-value	Parameters	Pearson Correlation	P-value
RH_0	0.493	0.087	MINT_0	-0.116	0.707
RH_1	0.593*	0.033	MINT_1	0.322	0.284
RH_2	-0.064	0.837	MINT_2	0.278	0.358
RH_3	-0.517	0.071	MINT_3	0.383	0.196
RH_4	0.032	0.918	MINT_4	0.491	0.088
RH_5	0.070	0.821	MINT_5	0.501	0.081
RH_6	0.242	0.425	MINT_6	0.102	0.740
RH_7	0.180	0.557	MINT_7	0.353	0.237
AVET_0	-0.405	0.170	MAXT_0	0.016	0.958
AVET_1	-0.337	0.261	MAXT_1	-0.346	0.246
AVET_2	0.115	0.708	MAXT_2	0.065	0.833
AVET_3	0.660*	0.014	MAXT_3	0.508	0.076
AVET_4	0.365	0.220	MAXT_4	0.038	0.903
AVET_5	0.157	0.609	MAXT_5	0.025	0.936
AVET_6	-0.047	0.879	MAXT_6	-0.301	0.317
AVET_7	0.114	0.711	MAXT_7	0.074	0.810
			RAINF_1	0.396	0.181

Note: * significant at 5% level.

The plot maps relative to the CBPD incidence were drawn up from monitoring week 1 to week 50. The plot maps help the grower to understand the performance of individual cocoa trees against the CBPD in long term. The maps corresponding to the epidemic start and end dates with five weeks apart are displayed in Figure 6. The figure showed the spatial distribution of cumulative CBPD incidence seemed to begin disperse evenly in all groups with 34% trees infected with CBPD in week 1 and increased rapidly to 80% in week 5 and infected almost all trees to reach 93% at week 50.

In the case of yield loss due to CBPD, 6% to 12% cocoa trees had recorded moderate losses of 36% to 55% from week 5 to 45 but reached 22% cocoa trees at week 50. The disease seemed to appear on certain groups such as group 1, 3, 4, 5, 6, 7, 8, 9,, 10, 11, 12 and 13. For heavy losses more than 55%, only 2 trees have been recorded in week 10 but increased to 4 trees after week 15 and later reached to 9 trees at week 50. The groups involved in heavy losses were groups 6, 7, 10, 11, 12 and 13.

In addition to the trees not productive, the last observation week, there were also some trees that were not affected by the disease at all. The cocoa trees looked not productive including tree number of 22, 59 and 63 while there were four cocoa trees looked resistant to the CBPD including tree number of 18, 21, 54 and 72.

Table 2 gives the statistics of Moran's *I* test on the cumulative CBPD per tree for different weeks. The result showed the *I* index was only significant in week 10 while other weeks were not significant at 5% limit. This was to confirm the absence of any spatial correlation in the study plot on observation weeks except week 10. The Moran's *I* value in week 10 is positive (Moran's *I* = 0.194), indicating that there is an overall pattern of clustering of cumulative CBPD. The reasons of not significant of spatial autocoorelation values among the individual trees in the plot on most of weeks were caused by cocoa farm was mostly characterised by strong spatial heterogeneity that linked to the existence of other intercropping trees and gaps left by unreplaced dead trees plus with the pod distribution within trees is also heterogenous (Ndoumbé-Nkeng *et al.*, 2004).

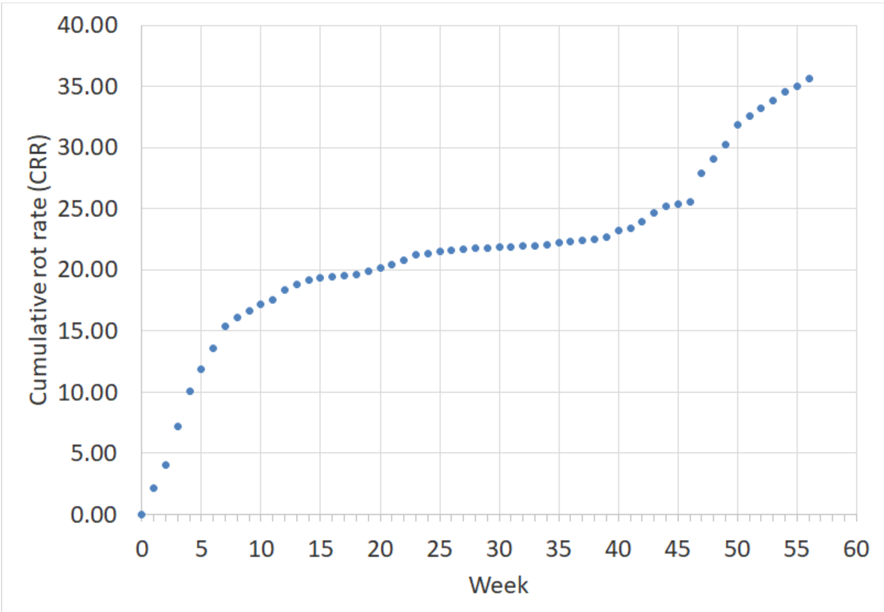

Figure 5. Progress of cumulative CBPD in subplot 1, CRDC Kota Samarahan from December 2019 to April 2021

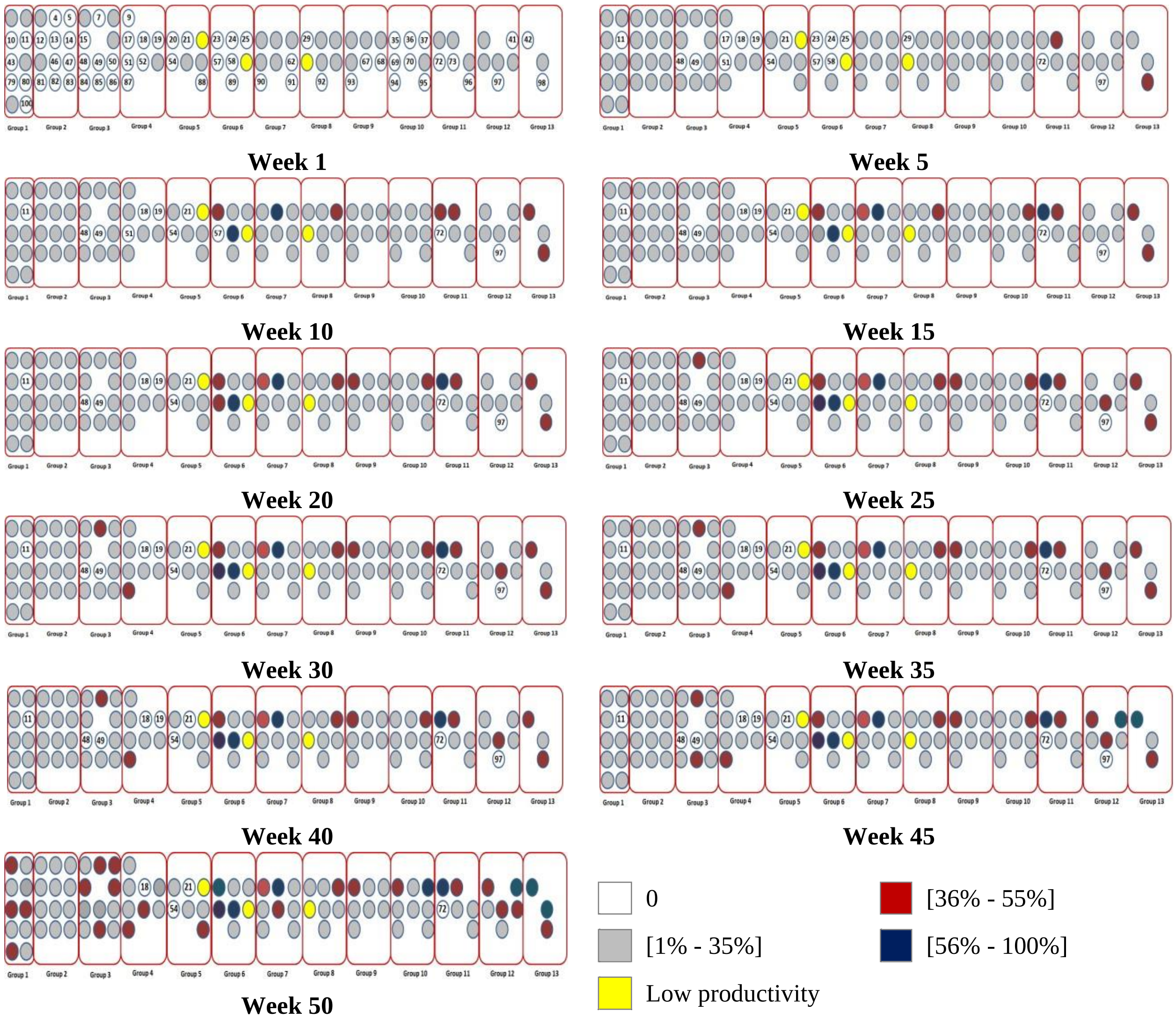

Figure 6. Spatial distribution of Cumulative Rot Rate of cocoa trees in subplot 1, CRDC Kota Samarahan from December 2019 to April 2021

Table 2. Moran's Index *I* of Cumlative Rot Rate from December 2019 to April 2021

Week	*I*	Z value	P-value
1	-0.086	-0.607	0.272
5	0.066	0.592	0.277
10	0.194	1.675	0.047
15	0.193	1.642	0.050
20	0.192	1.623	0.052
25	0.097	0.856	0.196
30	0.084	0.752	0.226
35	0.067	0.618	0.268
40	0.071	0.651	0.257
45	0.067	0.615	0.269
50	-0.024	-0.108	0.457

CONCLUSIONS

This work was to explain how the data-based monitoring system can be created to assist the cocoa growers in managing the cocoa farm in handling the problem of CPBD. This system was designed using Pivot Tables in Microsoft Excel which was available in most of the computer and it able to guide the growers to make decision based on the right timing to take action in order to reduce the losses and achieving better cost-benefit ratio. Three graphs was created from the Pivot Tables to guide the growers what need to be done in managing the problem of CBPD at the earlier stage. First graph was assisting the grower to monitor the monthly performance of cocoa trees in the plot and identify which month having higher incidence. Second graph was to focus on the higher incidence month and identify the groups that contributed to the increased CPBD rate. The third graph was to determine the individual cocoa trees in Group that gave higher disease incidence. Grower can take actions either on the groups or identified individual cocoa trees contributed to higher incidence. Beside that, the growers can observe any increased in relative humidity at lag 1 day may increase the incidence. The growers can use the disease distribution maps and spatial autocorrelation analysis to provide a clearer understanding of the spread of the cumulative CBPD in the plot in long term monitoring plan. Based on the disease distribution maps, suggestion for immediate actions can be taken by focusing on the infected cocoa trees that achieved more than 35% incidence to reduce the incidence of the CBPD in the plot.

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