AN INVESTIGATION OF CPB INFESTATION PATTERN WITH GIS APPROACH, SPATIAL AND TEMPORAL ANALYSIS ON COCOA FARM IN SIN ONN, TAWAU, SABAH.

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ABSTRACT - *Cocoa Pod Borer (CPB), Conopomorpha cramerella Snellen (Lepidoptera: Gracillariidae), is an economic important pest of cocoa. The CPB larvae are able to reduce bean quality and production. Various methods have been developed to manage and control the pest effectively. Continues study on the pest however still relevant to get more information so that control methods can be improved further more. It is handy in precision agriculture to have foreknowledge of infestation pattern on the farm area. Such information is crucial in devising a management strategy that precise and cost effective to control the pest. Hence a study was conducted for the period of Nov 2017 to Mar 2020 on one hectare farmers cocoa field in Sin Onn, Tawau, Sabah. The cocoa field was divided into 60 small plots and Global Positioning System (GPS) coordinates were recorded. On each small plot, CPB infestations which are the Average Damage Severity Index (ADSI), larva entry and exit hole, and wet bean weight were recorded. The data obtained were interpolated into Geographic Information Systems (GIS) mapping to visually observing the spatial and temporal distribution pattern. The GIS map information of CPB infestation was discussed on its important for formulating a management strategy to control the pest in precision agriculture of cocoa.*

Key words: CPB infestation, precision agriculture, CPB control, GIS mapping, pest management

INTRODUCTION

Cocoa is still the third important plantation commodity in Malaysia. However, the cultivated area has been reduced over the time and most of the cultivated area is owned by the small holder. Many factors were involved in the yield reduction among them is the pest, and major pest of cocoa is CPB, *Conopomorpha cramerella* Snellen (Lepidoptera: Gracillariidae) (Navies, 2020). A recent technology to control the CPB is the integrated pest management approach (Navies *et al.*, 2016; and Navies, 2020). However Malaysian Cocoa Board (MCB) is keen to modernise the cocoa cultivation in Malaysia by looking into the more precise method with incur increasing in productivity with optimum agriculture inputs. This can be achieved through precision agriculture and the IPM approach as both technologies encourage precise and targeted application of agriculture input (Usman *et al*., 2019).

Precision Agriculture is a management strategy that gathers, processes and analyzes temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production (Demir and Aydin, 2018; and ISPA, 2021). The technology has been used in other crops such as citrus (Martinez-Ferrer and Campos-Rivera, 2017) and oilseed rape (Andrew *et al*., 2003) to manage the agriculture inputs. In order to use precision agriculture in managing the pest, extensive early study is needed to obtain data on its spatial and temporal distribution (Richard *et al*., 1998; Andrea and Pasquale, 2014; Martinez-Ferrer and Campos-Rivera, 2017; and Holloway *et al*., 2020).

Research related to the field of precision agriculture technology in cocoa has been done in Ghana (Bosompem, 2021; and Bosompem *et al*., 2011). Their study goal on precision agriculture implementation was for managing and distributes fertilizer on site- specific to maximise long term benefits. Later they also determined the challenge to precision agriculture development in Ghana which they found out that the main challenges was farmer-demographic. In Malaysia, MCB is looking forward to explore broader usage of precision agriculture and not only on fertilizer. In this study we will look into acquiring the spatial and temporal distribution information of cocoa pest, the CPB, in the field. It is because CPB is still a concerning pest of cocoa in Malaysia. As part of farm management going to be inline with the current technology trend towards digital and Internet of Things (IoT) (; Bruno *et al*., 2021; and Brandoli *et al*., 2021) , it is necessary for such as this study to be conducted in cocoa cultivation.

MATERIALS AND METHODS

The study was conducted on a hectare cocoa field at farmer's farm located at Sin Onn (4.2983° N, 117.9245° E), Tawau, Sabah, Malaysia as in Figure 1. The cocoa farm had been rehabilitated for about 20 years ago. Cocoa clone cultivated by the farmer were PBC 123 and BR 25. Field maintenance was conducted by the farm worker and occasionally helped by our staffs especially on pruning. A handheld global positioning satellite GPS tracking, Garmin eTrex Vista® was used to record the GPS coordinate on each plots. Data of CPB infestations which are the average damage severity index (ADSI), larva entry and exit hole, and wet bean weight were recorded fortnightly on each plot.

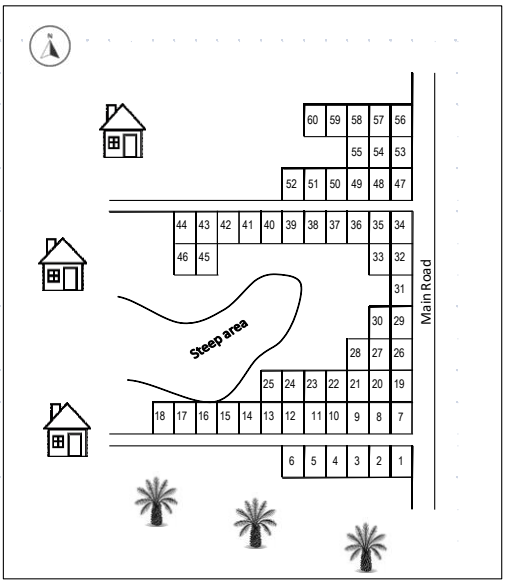


Figure 1: Simple map of the cocoa farm to indicate 60 plots and the surrounding area.

A Pearson's correlation analysis was used to investigate the relationship between the parameters that acquired in the study. Further more data were graphically analysed by plotting a map using GIS mapping software. The maps generated are to observe the dynamic of parameters in term of spatial and temporal distribution.

RESULTS

The relationship among the parameters was presented as on Table 1. The sum of wet bean weight relationship with the CPB infestation parameters (ADSI, entry hole and exit hole) was observed to be negative and the strength increased toward the end of observation period. The relationship between ADSI, entry hole and exit hole was observed always in positive and increased to the end of observation period.

Table 1: Parameter's average on each sampling period**.** (N=60; Mean ± Standard Deviation)

Sampling Period	Wet bean weight (Kg)	ADSI	Larvae entry hole	Larvae exit hole
NOV 17 – MAY 18	2.19 ± 1.54	3.01 ± 0.34	4.49 ± 0.81	1.97 ± 0.32
JUN 18 – OCT 18	2.66 ± 3.91	2.82 ± 0.50	4.61 ± 1.33	2.47 ± 0.74
NOV 18 – APR 19	1.72 ± 1.73	2.94 ± 0.35	3.91 ± 0.63	2.60 ± 0.45
MAY 19 – OCT 19	2.05 ± 2.02	3.07 ± 0.45	5.04 ± 0.92	3.26 ± 0.61
NOV 19 – MAR 20	0.58 ± 0.53	3.34 ± 0.43	6.72 ± 1.24	3.92 ± 0.93

Table 2: Pearson's correlation analysis of CPB infestation, damage and yield throughout the duration of study (N=60).

Parameter	Sampling Period	Sum of wet bean weight	Average ADSI	Average of entry hole
Average ADSI	Nov 2017 - May 2018	-0.47		
	Jun 2018 - Oct 2018	-0.40		
	Nov 2018 - Apr 2019	-0.63		
	May 2019 - Oct 2019	-0.71		
	Nov 2019 - Mar 2020	-0.64		
Average of entry hole	Nov 2017 - May 2018	-0.03	0.29	
	Jun 2018 - Oct 2018	-0.45	0.55	
	Nov 2018 - Apr 2019	-0.66	0.71	
	May 2019 - Oct 2019	-0.72	0.83	
	Nov 2019 - Mar 2020	-0.63	0.68	
Average exit hole	Nov 2017 - May 2018	-0.03	0.30	0.92
	Jun 2018 - Oct 2018	-0.36	0.51	0.88
	Nov 2018 - Apr 2019	-0.64	0.71	0.90
	May 2019 - Oct 2019	-0.68	0.87	0.88
	Nov 2019 - Mar 2020	-0.61	0.71	0.81

The spatial and temporal distribution map patterns were on Figure 2 and Figure 3. Graphically, it was found that the CPB infestation parameters concentrated on the north part of the cocoa farm for the entire study duration. Scattered hot spot area of high incident CPB infestation however observed on sampling period of JUN 2018 - OCT 2018. The wet bean weight harvested was appeared to be similar on most of the sampling period (Figure 3). However, hot spot for yield (wet bean weight) observed on the southeast part of the cocoa farm on JUN 2018 – OCT 2018.

In order for a clear understanding of the parameters relationship, their data were also displayed as line graphs throughout of the study duration (Figure 4). In that figure, all CPB infestation parameters were fluctuated in similar pattern according to sampling plot on the entire of the study duration. The yield (wet bean weight) recorded higher at JUN 2018 – OCT 2018. The lowest yield was on NOV 2019 – MAR 2020 which all sampling plots produce less then 5 Kg.

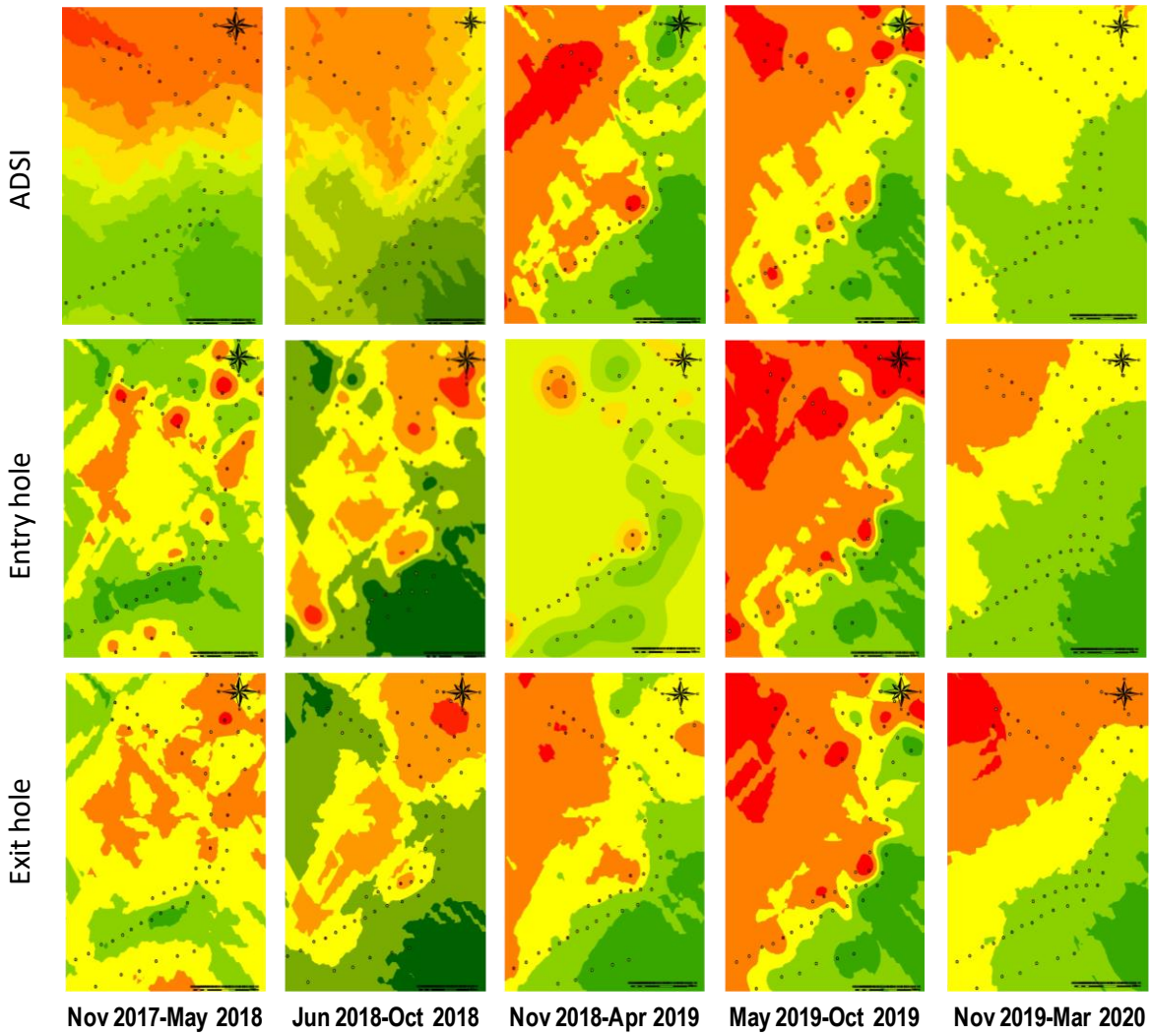


Figure 2: GIS plot of ADSI, entry and exit hole as an indicator for CPB infestation spatial and temporal distribution. Colour indicate that low (dark green-light green), intermediate (yellow) and high (red-orange).

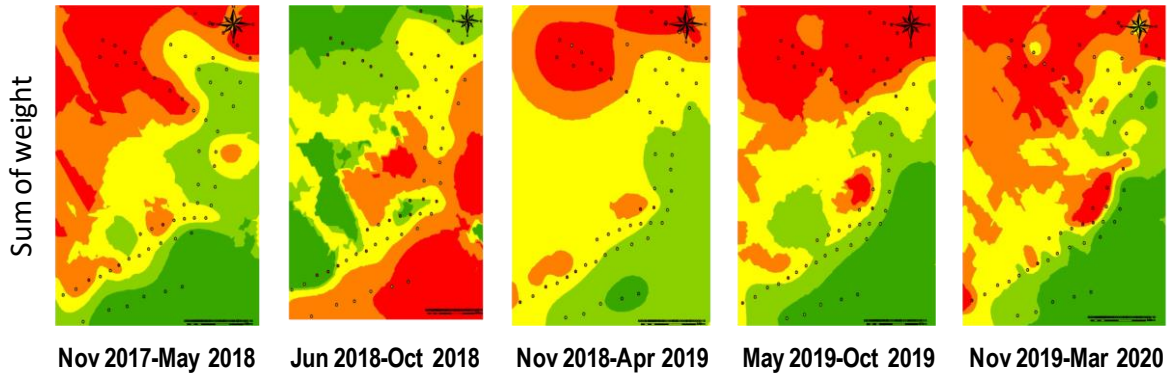
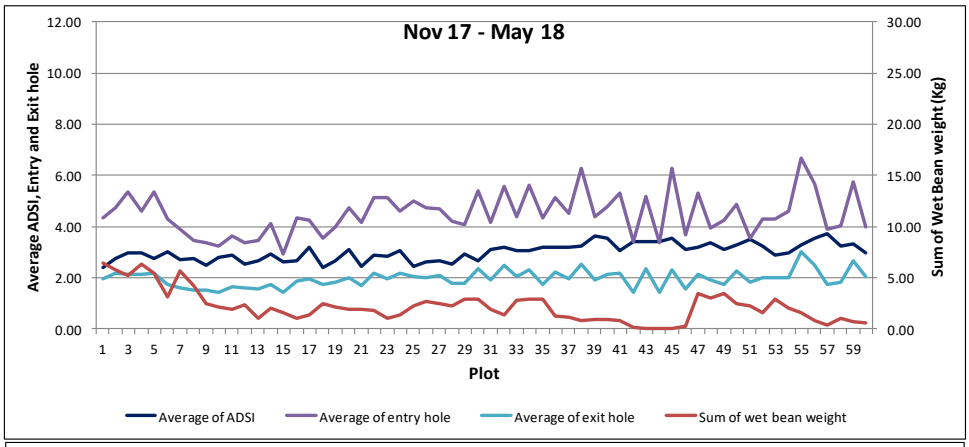
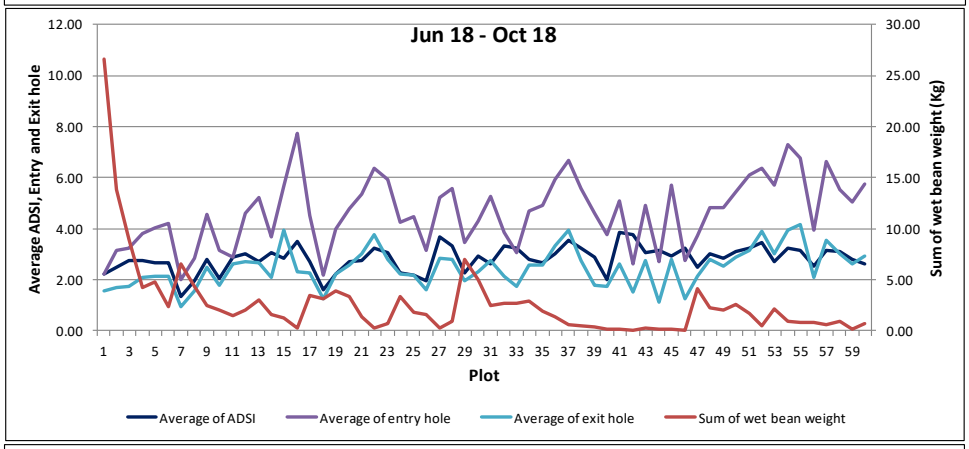
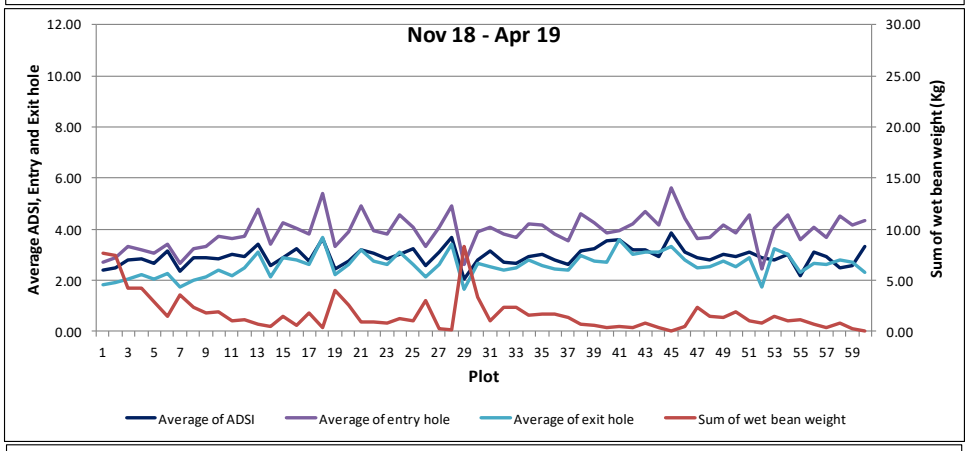
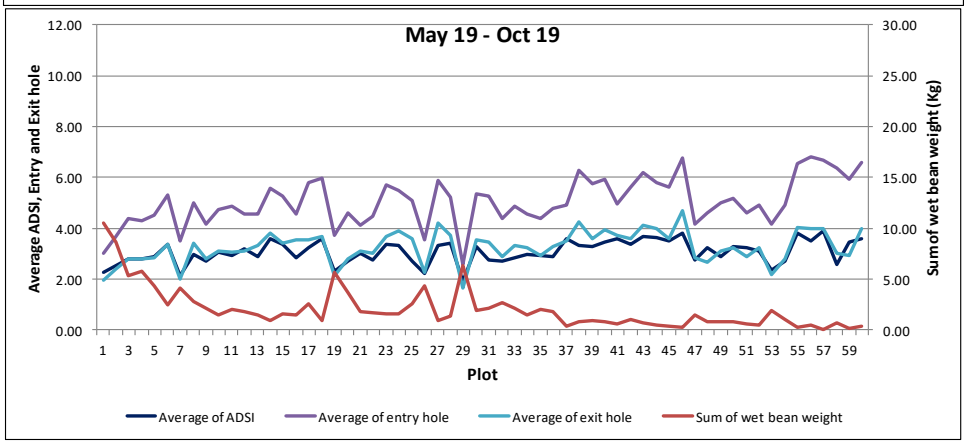


Figure 3: GIS plot of sum of wet bean weight (Kg) spatial and temporal distribution. Colour, indicate that low (dark green-light green), intermediate (yellow) and high (red-orange).


Nov 17 - May 18
Average ADSI, Entry and Exit hole
Sum of Wet Bean weight (Kg)
Plot
Average of ADSI
Average of entry hole
Average of exit hole
Sum of wet bean weight


Jun 18 - Oct 18
Average ADSI, Entry and Exit hole
Sum of wet bean weight (Kg)
Plot
Average of ADSI
Average of entry hole
Average of exit hole
Sum of wet bean weight


Nov 18 - Apr 19
Average ADSI, Entry and Exit hole
Sum of wet bean weight (Kg)
Plot
Average of ADSI
Average of entry hole
Average of exit hole
Sum of wet bean weight


May 19 - Oct 19
Average ADSI, Entry and Exit hole
Sum of wet bean weight (Kg)
Plot
Average of ADSI
Average of entry hole
Average of exit hole
Sum of wet bean weight

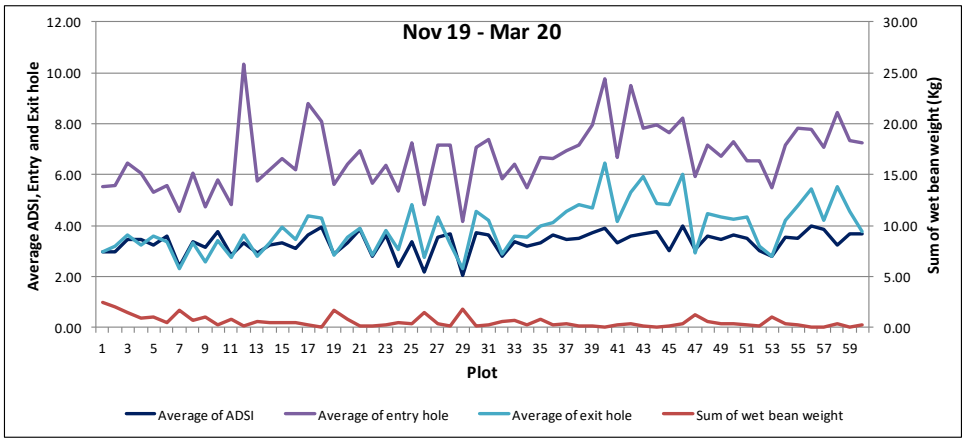


Figure 4: CPB Infestation parameters and sum of wet bean weight over the study plot for the entire study duration, NOV 2017 – MAR 2020.

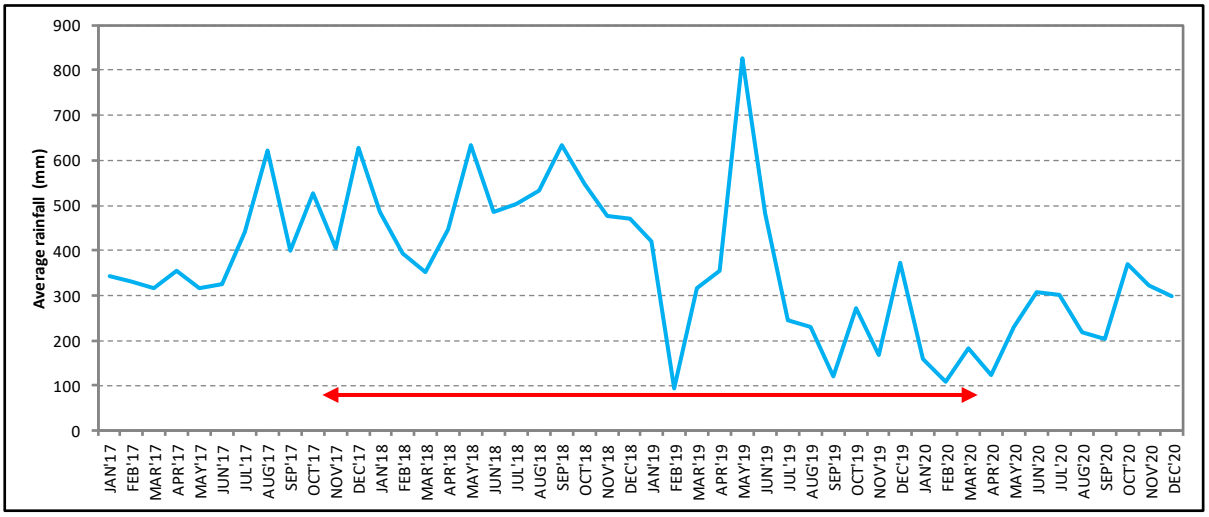


Figure 5: Monthly average rainfall (mm) for the period of JAN 2017 – DEC 2020 for Tawau, Sabah, Malaysia. Data source, WorldWeatherOnline.com. Red arrow line indicates the study duration.

DISCUSSIONS

All the parameters for this study were observed to have a relationship (Table 1). As results of the correlation shows that yield (wet bean weight) have been negatively correlated to the CPB infestation parameters (ADSI, larva entry hole and exit hole). It was expected as CPB is known as pest of cocoa. While the correlation between ADSI, larva entry and exit hole were positively correlated. These relationships were supported by the plotted maps through GIS software (Figure 2 and 3) and line graphs as in Figure 4.

On the maps, it was observed that the CPB infestation and damage trend found to be similar throughout the observation period from NOV 2017 to Mar 2020. The reason was that CPB was not moving around often to conserve its energy. Most hot spot of CPB infestation throughout of the study were on northern west part. In that particular area, it is in a similar altitude about 60 meters above sea level. While on the southern east part it is on the higher altitude about 80 meters above sea level. Another reason was the farm worker activities more on the area near to the main road.

The yield (wet bean weight) hot spot found to be following the trend of CPB infestation. However, on JUN 2018 – OCT 2018 where the hot spot was on the southern east part of the farm. On that period, the farm was produced more pods thus the yield was recorded high (Figure 4). On the other observation periods, yield was low because of various factors such as the farm worker not following recommendation on how to manage the cocoa. Therefore, pest control was not executed thoroughly. Another contributing factor was the weather (climate) as observed by Castex *et al.* (2018) that both insect and plant depend on it for

their development. On Figure 5, optimum monthly rainfall was observed between AUG 2017 to DEC 2018, it was another reasons why on JUN 2018 – OCT 2018 higher yield of that farm was recorded.

After DEC 2019, only at MAY 2019 recorded higher rainfall and the rest of the observation period received less rain. This phenomenon affected the on set of cocoa pod production and cocoa tree on the higher altitude affected the most. Yield by the plot on each observation period as on Figure 4 when compared to the rainfall as in Figure 5 clearly shows the effect of rainfall. Due to prolonged dry weather, by the end of the study period NOV 19 – MAR 2020, yield on that farm recorded the lowest (below 5 Kg per plot).

CONCLUSIONS

This study concluded that spatial and temporal distribution trend of yield was more dynamic. It was because many factors do affect the yield such as soil fertility, weather, pests and diseases, and human factors. Here we are looking more to the spatial and temporal distribution trend of pest, the CPB. It was found that in this study the hot spot of CPB infestation tend to be similar throughout of the observation period. In this particular cocoa farm, most of the infestations were on the northern west part. This information can be used to formulate a strategy CPB control for this farm with IPM approach together with precise amount of insecticide and more targeted practice. We expect that other farm may produce similar trend on spatial and temporal distribution of CPB, however the hot spot and the map pattern may differ.

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