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Research Article

Detection of Cocoa Pod Borer Infestation Using Sex Pheromone Trap and its Control by Pod Wrapping

Deteksi Serangan Penggerek Buah Kakao Menggunakan Perangkap Feromon Seks dan Pengendaliannya dengan Pembrongsongan Buah

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ABSTRACT

Cocoa pod borer (CPB), *Conopomorpha cramerella* Snellen (Lepidoptera: Gracillariidae) is a major pest of cocoa. Detection of the pest infestation using sex pheromone traps in the early growth and development of cocoa pods is important for an early warning system programme. In order to prevent the pest infestation the young pods were wrapped with plastic bags. A research to study the CPB incidence was conducted at cocoa plantations in Banjarharjo and Banjaroya villages, District of Kalibawang; Hargotirto and Hargowilis villages, District of Kokap; and Pagerharjo village, District of Samigaluh, Yogyakarta. The experiments design used RCBD with four treatments (sex pheromone trap, combination of sex pheromone trap and pod wrapping, pod wrapping, and control) and five replications. As many as 6 units/ha pheromone traps were installed with a distance of 40 m in between. Results showed that one month prior to the trap installation in the experimental plots there were ripen cocoa pods as many as 9-13%, which were mostly infested by CPB. During the time period of introducting research on August to Desember 2016 there was not rambutan fruits as the CPB host, hence the CPB resource was from infested cocoa pods. The CPB moth trapped as many as 0−7 (1.13 ± 0.14) moths/6 traps/12 observations. The seed damage due to CPB larvae in the pheromone trap treatments (23.98%) was relatively similar with the control (20.25%). Seed damage rate in combination treatment of pheromone trap and pod wrapping (0.59%) was relatively the same with the pod wrapping (0.20%). The pheromone trap was more usefull for monitoring tool rather than for control, meanwhile pod wrapping was an effective control measure of CPB.

Keywords: cocoa, CPB, detection, pod wrapping, sex pheromone trap

INTISARI

Penggerek Buah Kakao (PBK), Conopomorpha cramerella *Snellen (Lepidoptera: Gracillariidae) merupakan salah satu hama utama kakao. Deteksi serangan hama PBK dengan perangkap feromon seks pada awal pertumbuhan dan perkembangan buah kakao penting dilakukan sebagai sistem peringatan dini. Dalam upaya pencegahan serangan hama tersebut dilakukan pembrongsongan buah muda. Penelitian dilakukan di kebun kakao rakyat di Desa Banjarharjo dan Banjaroya, Kecamatan Kalibawang, Desa Hargotirto dan Hargowilis, Kecamatan Kokap, serta kebun PT Pagilaran di Desa Pagerharjo, Kecamatan Samigaluh, Yogyakarta. Percobaan dengan empat perlakuan (perangkap feromon, kombinasi perangkap feromon dan brongsong, brongsong, kontrol) dan lima ulangan menggunakan rancangan RCBD. Perangkap feromon sebanyak 6 unit/ha dipasang dengan jarak antar perangkap sekitar 40 m. Hasil percobaan menunjukkan bahwa satu bulan sebelum pemasangan perangkap terdapat buah tua sebanyak 9−13 % dan umumnya terserang PBK. Selama kajian berlangsung tidak terdapat buah rambutan sebagai inang PBK sehingga sumber PBK diduga hanya dari buah kakao yang terserang. Ngengat PBK yang tertangkap yaitu sebanyak 0−7 (1,13±0,14) ekor/6 perangkap/12 pengamatan. Intensitas kerusakan biji akibat ulat PBK pada perlakuan perangkap feromon (23,98%) relatif sama dengan kontrol (20,25%). Kerusakan biji kakao pada perlakuan kombinasi perangkap feromon dan pembrongsongan (0,59%) relatif sama dengan pembrongsongan saja (0,20%). Perangkap feromon lebih berfungsi sebagai alat monitoring daripada alat pengendalian PBK, sedangkan pembrongsongan buah merupakan teknologi pengendalian PBK yang efektif.*

Kata kunci: deteksi, kakao, PBK, pembrongsongan buah, perangkap feromon seks

INTRODUCTION

Cocoa is a competitive commodity in Indonesia. The Cocoa Pod Borer (CPB), *Conopomorpha cramerella* Snellen (Lepidoptera: Gracillariidae) is a pest that threaten the cocoa industry and lead to the technical constraint of cocoa production (Wiryadiputra, 1996). Feeding activity of the CPB larvae results in sticky and undeveloped seeds which make the seeds to be small and stick to each other and to the fruit wall. This happens because the larvae attack pulp placenta and food tissue of the seeds (Depparaba, 2002). As a result nutrient supply to the bean is interrupted and the bean does not develop normally.

The data and information of the early detection program of pests infestation are essential for early warning system (EWS). One of the detection techniques is using a sex pheromone trap. The trap has been available in the market. It consists of synthetic pheromone EZZ and EEZ isomer of 4, 6, and 10-hexadecatrienyl acetate, alcohol as appropriate (the corresponding alcohols) and hexadecyl alcohol (Beevor *et al.,* 1986). The use of sex pheromone for monitoring or mass trapping of CPB is one promising IPM components. Sex pheromone is adventageous since it has specific targets, and is environmentally friendly, effective, and economical (Sulistyowati, 2014). Furthermore, the control can be achieved when many male moths are caught before mating, helping to reduce the number of hatched eggs (Beevor *et al*., 1986).

This study was intended to test the effectiveness of sex pheromone trap for detecting the existence of CPB in the cocoa plantation and to test the effectiveness of the pod wrapping. Host plants of CPB are specific on cocoa (*Theobroma cacao* L) and *rambutan* (*Nephelium lappaceum*) (Bradley, 1986). The infestation source of CPB is possibly coming from infested both crops. When the CPB moths are trapped before fruiting, it indicates that there is a threat of CPB infestation. Detection data of pest attack are useful as a basis for recommendations of rapid response to the pest infestation in the CPB integrated pest management system. The rapid response to the EWS was, among others, by pod wrapping.

MATERIALS AND METHODS

Field experiment was conducted in September 2016 until December 2016 in Kulonprogo Regency. The area was chosen as a location for study because the chronic and endemic CPB pest infestation and the widest cocoa farm are found in this regency of Yogyakarta. Multiple cropping of cocoa plantations at Banjarharjo and Banjaroya villages, Kalibawang District, Hargotirto and Hargowilis villages, Kokap District, and monoculture of cocoa at Pagerharjo village, Samigaluh District were taken for the experimental location.

The sex pheromone trap used to detect present CPB. The trap consisted of pheromonoid within a tube, yellow trap, and glue. The trap was hung on a bamboo stick at 50 cm above the cocoa canopy. For preventing the damage on young cocoa pods (8−10 cm in length), the pod was wrapped with a plastic bag. The cocoa pod wrapper is made from a paralon which is 3 inches in diameter and 1.5 m in length. At one of the paralon mouths, the lip is cut off in 2 cm × 2 cm size and then a rubber ring is installed thereon. A plastic bag of 2.5 kg size with two mouths is wrapped on the paralon. The plastic bag is then tied with the rubber ring by folding the plastic bag on the rubber ring. The plastic bag together with the rubber ring is pulled back. This one is repeated several times until the paralon is able to keep more than 20 plastic bags. The way to wrap cocoa pods is as follows. The mouth of paralon is placed to a cocoa pod which has 8−10 cm length until the paralon lip touches the branch. The rubber ring and plastic bag that is located on the outermost of the paralon and closing the 2 cm × 2 cm hole is then lifted and pushed forward with a stick until the plastic bag is released and held on the pod stalk by the rubber ring. The observation object is the cocoa moth which is trapped in the trap, and either healthy or infested ripened cocoa pods.

The Randomized Completely Block Design (RCBD) was applied for single factor experiment with four levels, i.e.: (1) sex pheromone trap, (2) combination of sex pheromone trap and pod wrapping, (3) pod wrapping, and (4) control, with five replications. Each treatment was placed on a plot of 1 hectare of cocoa plantation and the distance between the treatment plots was about 200 m. The experimental method of Sulistyawati (2014) was adopted and modified. Pheromone traps as many as 6 units/ha were installed in the plot within 40 m in between. The control was a plot without pheromone trap or pod wrapping.

Generative stages of the cocoa were observed several days prior to treatment. Observation on population of trapped moth was conducted every week during 12 consecutive weeks. Observation on fruit and seed damage was conducted on 1,072 sample product at harvest time. As many as 12 sample trees per plot for each hectare were taken at random. They are 6 trees closed to the traps and 6 trees that were 40 cm or 5 trees a way from the trap. In the control plot, 12 sample trees were taken at random with the distance of 5 trees in between. The pheromone trap function as a detection tool of CPB infestation was determined by the number of trapped CPB moth. The function of pheromone trap with combination pod wrapping to control the CPB was measured by the seed damage rate. ANOVA and DMRT on $\alpha_{0.05}$ were applied to calculate the significance of both pest control measures effectiveness against the CPB.

RESULTS AND DISCCUSSION

Condition of Cocoa Plantation Prior to Treatment

The monoculture of cocoa was observed in Pagerharjo village and the mix cropping of cocoa with other crops was observed in villages of Banjarharjo, Banjaroya, Hargotirto and Hargowilis. Amongst cocoa, there are coconut palms (*Cocos nucifera*), durian (*Durio zibethinus*)*, rambutan* (*Nephelium lappaceum*)*,* banana (*Musa paradisiaca*)*, sengon* (*Albizia chinensis*)*, matoa* (*Pometia pinnata*)*, petai* (*Parkia speciosa*)*, melinjo (Gnetum gnemon)*, salaca (*Salacca edulis*), and jackfruit (*Artocarpus integra*). In August–December 2016 as which the experiment was conducted, there was no *rambutan* fruits, hence, the CPB resource was only from infested ripened cocoa pods. The cocoa was planted at elevation of 100−200 m above sea level (asl) in Kalibawang District, 200−300 m asl in Kokap District, and 500−600 m asl in Samigaluh District.

The cocoa trees in Kalibawang and Kokap District were about 4−5 m tall and seemed to be less cared. Meanwhile, the cocoa trees in Samigaluh District were about 3−4 m tall and well cared. The unwell-cared cocoa trees provide a good habitat for pests and diseases development. All cocoa trees in all districts produced flowers, young small pods, young pods, and ripen pods. Wet dry season of 2016 might induce the cocoa to produce various stages of pod development.

Composition of Cocoa Fruits

In September 2016 cocoa plantation at all experimental locations in districts of Kalibawang, Kokap, and Samigaluh, were under conditions of flowering and fruiting (Table 1). Flowers were more predominant than fruits, meanwhile the ripen cocoa pods were observed on treatments as many as 9 to 13%. Most of the ripen pods were infested by CPB (Figure 1a). The CPB hosts are always available during the season, hence, the life cycle of CPB is believed to never end.

The moths attracted to the yellow trap and sex pheromonoid then stuck on the glue, and eventually died (Figure 1b,c). Sex pheromone trap can be catch mass of male CPB, hence, a mating disruption trial was shown to reduce mating of female (Alias *et al.*, 2004). Syarkawi *et al*. (2015) stated that factors enhancing the CPB existence is the availability of fruits in the fields which influence the infestation rate of the CPB. The more abundant the host, the higher the CPB density, which in turn will cause heavy damage on cocoa pods.

The CPB moth population showed fluctuation at every observation. One week after the traps were installed, the number of trapped moth was at most than in the following weeks of observation (Figure 2). The decreasing trend of CPB moth population is alleged due to the concentration of pheromone decreases. Although number of CPB trapped just a little, but allegedly the moth trapped source from field trial. The allegedly on the time of observation there was not rambutan fruit as host alternative of CPB and there was ripen cocoa pods infested the CPB as the resource present the moth in trial location.

The fluctuation moth trapped once 16 weeks alleged due to the pheromone factor that the reduced concentrate of sex pheromone or alleged the CPB population was down. According to Zhang *et al.* (2008) the experiment in Sabah, Malaysia, pheromone concentration after 1 and 2 month reduced to around 62% dan 40% (concentrate 101.49 μg/lure), meanwhile Vanhove *et al*. (2015) pheromone concentration 100 μg/vial were effective for 6−8 weeks after that the effectiveness diminished rapidly. The decline of pheromone concentration and reduction of pheromone lure longevity over time may also contribute the

Table 1. Composition of the development of cocoa fruits in the experimental locations prior to treatments

Blocks	Sub Districts, Districts	Number of cocoa fruits																							
		Sex Pheromone						Sex Pheromone + Pod Wrapping						Pod Wrapping						Control					
		a	b	c	d	e	Σ	a	b	c	d	e	Σ	a	b	c	d	e	Σ	a	b	c	d	e	Σ
I	Banjarharjo, Kalibawang	217	72	89	81	55	514	232	67	91	211	96	697	267	83	95	123	53	621	272	89	93	44	18	516
II	Banjaroya, Kalibawang	166	117	112	98	77	570	248	94	107	101	36	586	189	107	101	105	70	572	227	97	133	104	99	660
III	Hargotirto, Kokap	81	12	41	18	26	178	145	43	61	24	57	330	149	41	52	34	33	309	101	21	81	36	57	296
IV	Hargowilis, Kokap	143	24	55	52	72	346	148	38	80	93	83	442	121	41	56	33	21	272	169	35	52	39	39	334
V	Pagerharjo, Samigaluh	239	92	119	188	67	705	116	63	79	179	65	502	354	150	93	252	68	917	244	67	106	157	63	637
Proportion (%)		37	14	18	19	13	100	35	12	16	24	13	100	40	16	15	20	9	100	41	13	19	16	11	100
Sample trees		12						12						12						12					

Note: Σ = sum total of a, b, c, d, e
a = flower
b = young pod <8 cm
c = young pod 8−10 cm
d = young pod > 10 cm
e = ripe pod

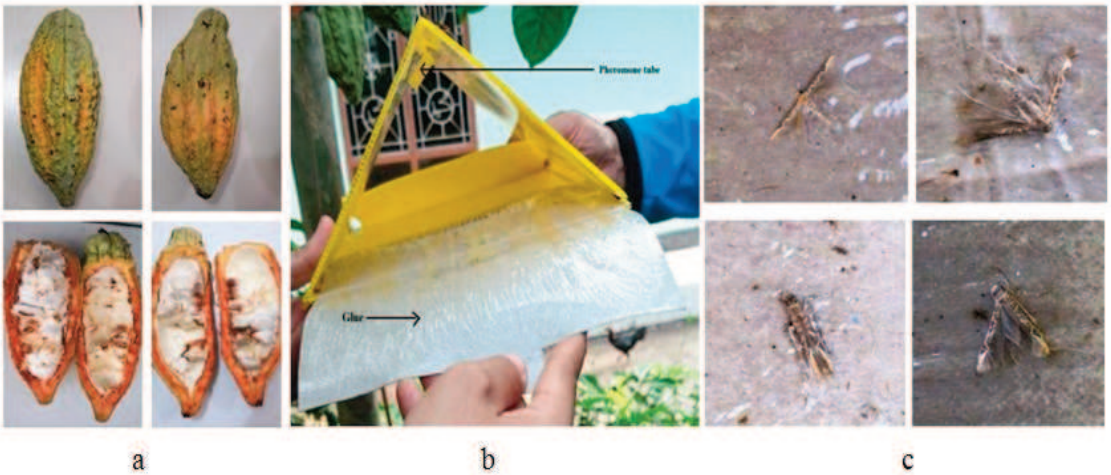

Figure 1. The infested cocoa pod by CPB at one month prior to trap installation (a); structure of sex pheromone trap (b), and CPB moth stuck and died on the glue (c)

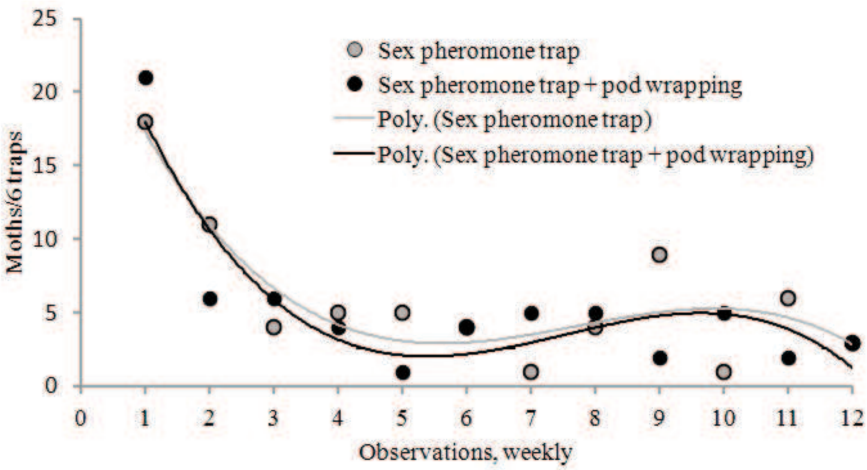

Figure 2. The fluctuation of CPB moth population during 12 observations in five locations

isomerization, oxidation and decomposition of the active pheromone components under the conditions of high temperature, humidity and rainfall in the cocoa plantation in Pahang, Malaysia (Vanhove *et al*., 2015).

The number of trapped CPB moths after 120 times was about 0−7 (1.13 ± 0.14) moths/6 traps. Average number of CPB moths which was trapped on pheromone treatment (1.18 moths/6 traps) was relatively the same with the combination treatment of pheromone and pod wrapping (1.07 moths/6 traps) (Figure 3). The number of trapped CPB moth on sex pheromone treatments was not significantly difference with at sex pheromone and pod wrapping combination treatment ($P > 0.05$), except in Banjaroya, where it was significant ($P<0.05$). The plant treatments and abiotic factors in each location of the study might affect the CPB population and distribution. Negara (2015), the difference in number of CPB trapped is possible because the difference in density of the pod cocoa on each tree per block.

In addition to the pheromone concentration, external factors might influence the cocoa growth and CPB population density, such as elevation, rainfall and careness of cocoa trees at each location. The environmental conditions may be very suitable for mating and egg laying so that the CPB populations develop well at the former elevation (Syarkawi *et al.,* 2015). Climate components like air temperature, sun radiation, rainfall and wind velocity are different at different elevations (Sangadji, 2001; Capinera, 2012). The climate is one of the abiotic factors that influences reproduction and orientation of insects at the time of food searching and causes change on the insect physiology (Gillot, 1982). The higher the elevation, the cooler the temperature, and the higher relative humidity the faster of the wind, and these things are believed to affect the insect distribution.

The overall environmental temperature affects the insects metabolism (Rockstein, 1973).

The insect population dynamics is closely related to the climate. The increase of CPB population at the elevation of 100−400 m asl is allegedly caused by all stages of the CPB at which they are in the optimal temperature range to develop (Syarkawi *et al*., 2015), while the decrease of the insect population may be caused by decreasing fecundity due to decreasing temperature (Hodkinson, 2005). Refering to Duyck *et al.* (2010), higher places can slow down the insect reproduction, hence, the number of insect generation and population tends to be less. Hoiss *et al.* (2012) stated that the number of insect species decreases as latitude or elevation increase. Refering to Wiryadiputra (1996) the CPB population generally will be less in the wet season and will be higher in the dry season. It is because of the high rainfall will affect moth mobility. In the dry season with increasing number of cocoa pods, the CPB population will fastly increase as well (Wardojo, 1980).

Control of CPB

The study expects for testing the sex pheromone trap to detect the CPB infestation, and also trying to combine it with cocoa pod wrapping using plastic bag to manage and control the pest. Cocoa pod wrapping with plastic bag was effective to reduce the cocoa seed damage. The pod wrapping is intended to prevent CPB moth egg laying activity (Wiryadiputra, 1996).

Number of boring hole per pod, pod damage, and damaged seed on combination treatment of sex pheromone and pod wrapping were significantly less than on treatment of sex pheromone and not significantly different with wrapping only (Table 2). With pod wrapping the female CPB moths can not lay their eggs on the pod surface (Wiryadiputra, 1996) and the larvae can not bor into the pod, hence, the pod damage can be reduced. The pod wrapping experiment were significantly to decrease the number of boring hole of CPB larvae with an average of 15 holes/pod (Fiana *et al.,* 2015). The pod wrapping can protect the healthy pods up to 83.9% (Moersamdono & Wardojo, 1984), even up to 97.38% (Senewe & Wagiman, 2010).

The sex pheromone in this study seemed to be less significant effect in controlling the CPB as indicated by the number of boring holes per pod, damaged pods, and damaged seeds, which were not different with the control. However, it is important to note that the data on damaged pods was just obtained at the harvest time. Meanwhile, the sensitive pods against the CPB infestation are when the pods are still very young (8−10 cm in lenght) (Sulistyowati, 2014). The CPB egg laying is occuring on cooca pods during 2−3 months prior to harvest and the damaged seed just can be observed only at harvest time (Imran & Sabur, 2014).

The sex pheromone trap is very useful to detect the early CPB infestation and monitoring. If at early growth and development of cocoa pods the male CPB moths were trapped, it a sign that the CPB infestation occurs in the cocoa plantation. Refering to Zhang *et al.* (2008), the development of cost-effective pest management strategies should also include pheromone-based monitoring, mass trapping,

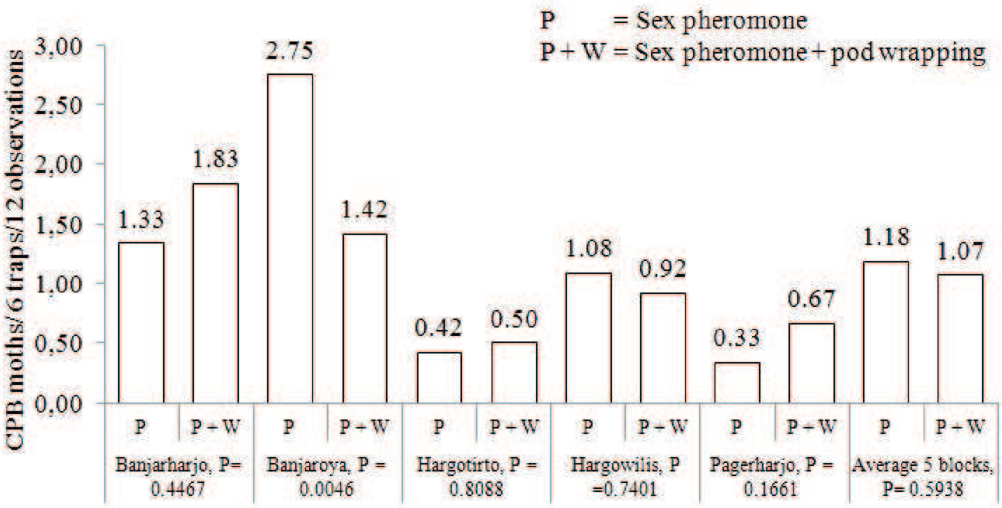

Figure 3. Average number of CPB moth on treatment of sex pheromone and combination treatment of sex pheromone and pod wrapping in five experimental locations

Table 2. The infested cocoa pod by CPB, number of boring hole, and damaged seed on four treatments

Subdistricts and districts	Damaged pods (%)				Number of bor holes/pod				Damaged seeds (%)			
	A	B	C	D	A	B	C	D	A	B	C	D
Banjarharjo, Kalibawang	65	9	0	47	1.98	0.18	0.00	0.90	22.25	0.76	0.00	19.56
Banjaroya, Kalibawang	63	0	0	55	1.88	0.00	0.00	1.18	20.77	0.00	0.00	15.20
Hargotirto, Kokap	72	9	0	90	2.8	0.12	0.00	2.63	25.77	2.08	0.00	35.97
Hargowilis, Kokap	82	4	6	65	1.89	0.03	0.14	1.77	48.68	0.11	1.02	27.51
Pagerharjo, Samigaluh	16	0	0	28	0.32	0.00	0.00	0.56	2.44	0.00	0.00	3.01
Average	60 a	4 b	1 b	57 a	1.77 a	0.07 b	0.03 b	1.41 a	23.98 a	0.59 b	0.20 b	20.25 a
CV	42	105	224	41	50.71	121.97	223.61	57.85	68.85	151.49	223.61	61.62

Description:
The everages within row followed by the same letters are not significantly different (P <0.05). Anova of transformed data into $Log_{10}(X + 10)$
A = sex pheromone trap
B = sex pheromone trap and pod wrapping
C = pod wrapping
D = control

and possibly mating disruption at a later date in addition to regular and complete harvesting. The important information still needed is the relationship between the number of male trapped moth and the predicted pod damage. In depth study to get the information need to be conducted in the future. Implication of the study results is that mechanical control measure with pod wrapping can be recommended for cocoa farmers. The sex pheromone trap is useful to detect the existence of the CPB infestation and also to monitor the pest.

CONCLUSION

The sex pheromone trap can catch the CPB moth. Damaged seed rate on the treatment of sex pheromone trap (23.98%) was relatively the same with control (20.25%). The damaged cocoa seed rate on combination treatment of sex pheromone trap with pod wrapping (0.59%) was not significantly different wrapping only (0.2%). The trap serves more as a monitoring tool rather than CPB control measure, meanwhile the pod wrapping was an effective CPB control measure.

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