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EFFECTIVENESS OF SEVERAL INSECTICIDES ON RED PALM WEEVIL, *Rhynchophorus ferrugineus* ON COCONUT PALM

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ABSTRACT

Although report on *Rhynchophorus ferrugineus* (RPW) attacking and damaging the oil palm is virtually absent, the potential of host shift from coconut to oil palm is awaiting as it closely related species the *R. vulneratus* and *R. schach* have been reported to attack oil palm in Malaysia, Indonesia and India. Currently, there has been no effective control method of RPW identified, other than destroying the breeding sites of the RPW. Thus, this study was conducted to evaluate the efficacy of selected chemical insecticides in controlling RPW within the coconut palm trunk. The study site was selected based on RPW infestation report by Department of Agriculture Malaysia (2019). All coconut palms in the area were confirmed on the RPW presence by using acoustic detection method and visual symptoms inspection. Three different chemicals were tested, namely acephate (organophosphate), cypermethrin (pyrethroid) and carbosulfan (carbamate). 30 g of acephate was delivered via trunk injection method, while cypermethrin were sprayed with 500 ml solution per palm, and 60 g of carbosulfan was placed on the crown of each palm. The effectiveness of treatments was measured by the presence or absence of RPW in the palm trunk via acoustic detection method, at weekly interval until 7 weeks after treatment. At one week after treatment, reduction of RPW presence was 87.5% when treated with carbosulfan, followed by cypermethrin (57.14%) and acephate (53.85%). No absence of RPW in control treatment. As a conclusion, the most effective chemical pesticide in controlling RPW is carbosulfan and can be considered in the integrated pest management of RPW.

Keywords: Integrated Pest Management, chemical control, Red Palm Weevil, acoustic

ABSTRAK

Walaupun laporan mengenai *Rhynchophorus ferrugineus* (RPW) menyerang dan merosakkan kelapa sawit tidak dilaporkan, potensi peralihan perumah daripada kelapa kepada kelapa sawit sedang menunggu kerana spesies berkait rapat seperti *R. vulneratus* dan *R. schach* dilaporkan menyerang kelapa sawit di Malaysia, Indonesia dan India. Pada masa ini, tiada kaedah kawalan berkesan RPW yang dikenal pasti melainkan memusnahkan kawasan pembiakan RPW. Justeru, kajian ini dijalankan untuk menilai keberkesanan racun serangga kimia terpilih dalam mengawal RPW dalam batang pokok kelapa. Tapak kajian dipilih berdasarkan laporan serangan RPW oleh Jabatan Pertanian Malaysia (DoA). Kesemua pokok kelapa di kawasan itu telah disahkan kehadiran RPW dengan menggunakan kaedah pengesanan akustik dan pemeriksaan visual simptom. Tiga bahan kimia berbeza telah diuji, iaitu acephate (organophosphate), cypermethrin (pyrethroid) dan carbosulfan (carbamate). 30 g acephate diberi melalui kaedah suntikan batang, manakala 500 ml larutan per pokok cypermethrin dengan kaedah semburan, dan 60 g karbosulfan diletakkan pada pucuk pokok kelapa. Keberkesanan rawatan diukur dengan kehadiran atau ketiadaan RPW dalam batang kelapa melalui kaedah pengesanan akustik bagi selang seminggu sehingga 7 minggu selepas rawatan. Pada satu minggu selepas rawatan, pengurangan kehadiran aktiviti RPW adalah 87.5% apabila dirawat dengan carbosulfan, diikuti oleh cypermethrin (57.14%) dan acephate (53.85%). Tiada ketiadaan RPW dalam rawatan kawalan. Kesimpulannya, racun perosak kimia yang paling berkesan dalam mengawal RPW ialah carbosulfan dan boleh dicadangkan dalam pengurusan perosak bersepadu RPW.

Kata kunci: Pengurusan Perosak Bersepadu, kawalan kimia, Kumbang Merah Palma, akustik

INTRODUCTION

Rynhchophorus ferrugineus (RPW) is an introduced, diurnal insect that can travel as far as 50km within 24 hours (Hoddle et al. 2015) and is more vigorous compared to the local species, *Rhynchophorus vulneratus* and *Rhynchophorus bilineatus* (Idris et al. 2014). Since *R. ferrugineus* is an introduced species, it is highly sexual with recorded time length before mating of only 1.83 minutes compared to *R. vulneratus* that was 11.25 minutes (Idris et al. 2014). The female RPW uses its long rostrum to dig hole in the host tissue before laying the eggs in the hole. The hatched larvae are the ones burrowing within the host's trunk that causes damage to the tissue, before pupating. These activities by RPW that caused, eventually death to the host plant. The damage of RPW was prevalent with records showing the drastic and rapid spread of RPW population in Malaysia (Azmi et al. 2017).

The *R. ferrugineus* is an economically important invasive tissue borer that has a broad host range restricted to palm trees, mostly young trees less than 20 years old (Faleiro 2006). Without proper control, it has been predicted that the damage to oil palm may be evident in 20-30 years' time (Idris et al. 2014). Currently, there is no effective control method of RPW identified, other than destroying the breeding sites of the RPW. The only method proposed in Malaysia was by using pheromone-based mass trapping system (Muhammad Firdaus et al. 2020), which is only useful in monitoring the population. Other countries with RPW problem was reported to be dependent on insecticides (Jalinas et al. 2015), including the use of diazinon, cypermethrin, imidacloprid and phosmet by various ways of application, preventively or curatively, depending on the types of chemical used (El-Mergawy & Al-Ajlan 2011). The

uncontrolled chemical treatments may lead to environmental damage and could possibly harm the non-targeted organisms, whilst cause the development of insecticide resistance among targeted pest. Thus, this study was conducted to evaluate the efficacy of selected chemical insecticides that are less hazardous, in controlling RPW within the coconut palm trunk. This method is only a part of integrated management of RPW, and should be applied in combination with other control methods, including cultural practices (field sanitation), biological control using effective pathogens, and awareness through trainings and education (Faleiro 2006).

MATERIALS AND METHODS

Sampling Site

This study was conducted in a one-acre smallholder coconut palm plantation in Rinching Hilir, Semenyih, Selangor, Malaysia (2°55'11"N 101°47'03"E). This site was chosen based on report by the Department of Agriculture, Malaysia (DOA 2019), based on the visual symptoms of RPW infestations (Harith-Fadzilah et al. 2020) and the detection of RPW adults' presence by pheromones traps (Azmi et al. 2014) (Figure 1)

Insect Sampling and Infestation Level

A total of 98 coconut trees were surveyed to assess the presence of RPW infestation based on visual symptoms and assisted with acoustic instruments. Acoustic Emission Device (AED) 2010 was used to detect the presence of RPW larvae inside the coconut trees (Figure 2). The trunk that near to the crown part were drilled up to 8 cm deep for the insertion of sensor's rod (Jalinas et al. 2015; 2017). A total of 180 seconds of sound was recorded for each tree (Figure 3). The score for level infestation of RPW were categorized based on the wavelength of sound recorded (Jalinas et al. 2015; 2017) into three categories I) No RPW Activity II) Low RPW acoustic activity and III) High RPW acoustic activity.

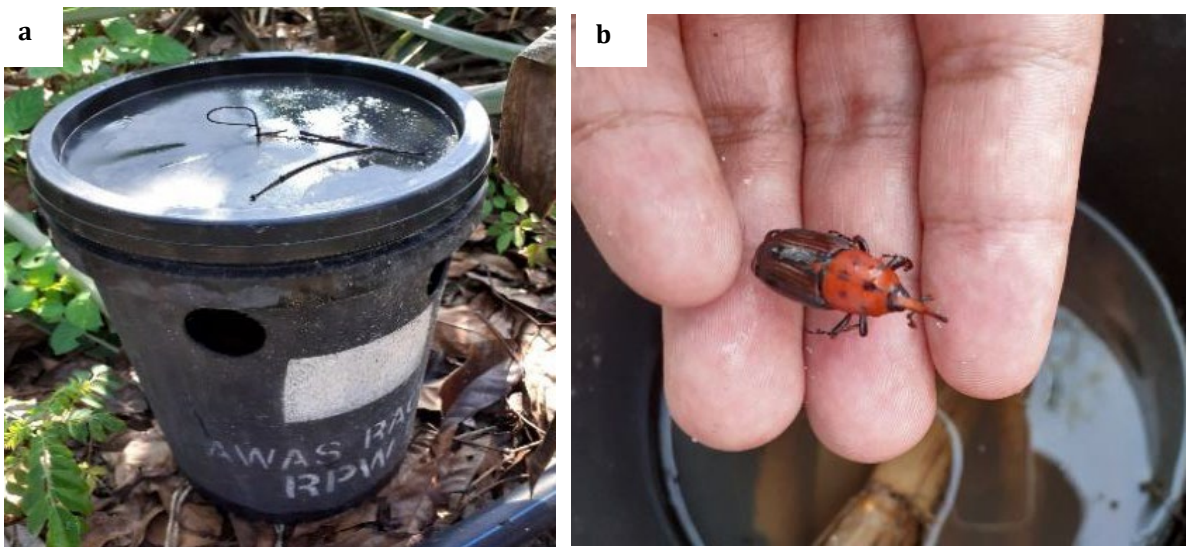

Figure 1. Detection of presence of RPW by pheromone traps, a) Pheromone traps (b) RPW captured by pheromone traps

Figure 2. Acoustic recording equipment, model AED 2010

Figure 3. Acoustic recording of RPW at the infested coconut trees

Chemicals Treatment

Three types of chemical insecticides (organophosphate), cypermethrin (pyrethroid) and carbosulfan (carbamate) were used on the infested coconut trees. The coconut tree plantation was divided into four different groups based on tree locations, which were for those three different insecticides and one control in order to find the best chemical insecticides to be used

as the most preferable control treatment. For acephate-based control, each tree was drilled for 8 cm deep into inside of the trunk, before being injected with 30g/ palm acephate inside the hole and then was covered with clay (Figure 4A). While for cypermethrin-based control, 500ml of the diluted chemical was sprayed on the left, the right and the upper crown (Figure 4B). Since carbosulfan is in granular form, 60g of the chemical was placed in bump-shaped before being placed at the crown area of each tree (Figure 4C).

Measuring effectiveness of Insecticides

The effectiveness of insecticides on the RPW were measured using the acoustic detection method. Insecticide treatments were considered effective if no RPW acoustic detected (Jalinas et al. 2017). Weekly observation on RPW activity was conducted in all trees by inspection using acoustic detection method whether severe (III), mild (II) or not (I) infested by RPW. The observation involved from the trees' inspections, chemical treatments until no more RPW acoustic activity inside the host recorded. The individuals of coconut trees were geotagged by the GPS coordinates. The maps for the spatial distribution of infested coconut trees (before and after treatments) were created in software QGIS 3.0.

Figure 4. Chemical treatments on infested coconut trees; A= trunk injection (acephate); B= crown spray (cypermethrin); C= crown bump placement (carbosulfan)

RESULTS AND DISCUSSION

Before treatment was conducted, 98 coconut trees in the area were successfully surveyed for evaluating and 34 trees (34.7%) were recorded with presence of RPW acoustic activity. Figure 5 shows the maps of healthy and infested coconut trees, based on acoustic detection method and visual symptoms inspection. This method was proven to be the best method in early detection of RPW (Jalinas et al. 2019) and termite species, *Coptotermes* sp. (Aliyah-Ahmad & Jalinas 2023), but requires time as the detection needs to be done for each individual tree. Hence, this method is not suitable for large area. For our study, we were able to use this method,

as the area used for the study was only about one acre. With the advancement of technology, a proper acoustic detection kit that is automated and could detect in a larger area would be achievable (Khudri et al. 2021).

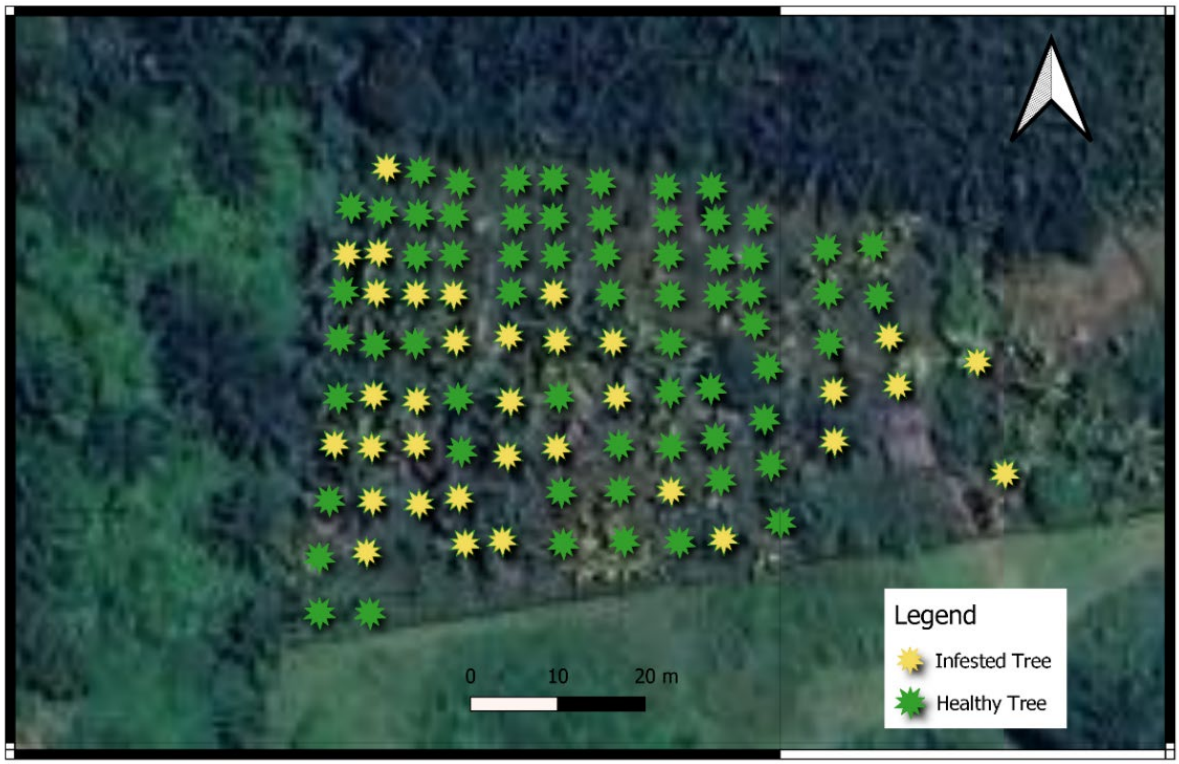

Figure 5. Healthy coconut trees (64 individuals) and RPW-infested coconut trees (34 individuals) based on the sound recorded by the visual symptoms inspection and acoustic detection method

Number of infested trees recorded were divided into two groups, namely high infestation level and low infestation level, based on the acoustic reading recorded before and after the treatment (Figure 6A & 6B).The treatments conducted using insecticides that were also being used for controlling RPW in Spain and the Middle East countries such as Egypt and UAE (El-Mergawy & Al-Ajlan 2011) High infestation level described as high number of RPW activities (high number of RPW present within the tree), while low infestation level described as low number of RPW activities (usually one or two RPW individuals present within the tree). Recording of RPW conducted a week after treatment showed reduction in infestation (Figure 6B).

Figure 6. Number of healthy and RPW-infested coconut trees, (A) during and (B) a week after the chemical treatment experiment conducted

Since the infestation is relatively new in Malaysia, the chemicals selected were based on the availability of the chemical locally for the control of rhinoceros beetles, *Oryctes rhinoceros* (Ismail et al. 2009; Martinez et al. 2014). Thus, the rate for each chemical were based on the treatment label for *O. rhinoceros.* Result showed a significant reduction of infested trees a week after the chemical treatment, based on insecticides tested ($t = 5.3862$, $df = 97$, $P = 5.026e\text{-}07$). Highest reduction was recorded in trees treated with carbosulfan (87.5%), followed by cypermethrin (57.14%) and acephate (53.85%) (Table 1). There were no decline, in term of numbers of infested trees in control plot. This study showed that chemical carbosulfan was found to be the most efficient chemical insecticides to be used in controlling RPW populations in palm trees.

Table 1. Percentage of infested trees based on treatment before and after experiment conducted

Type of Treatment	Number of RPW-Infested Coconut Trees		Percentage of Reduction (%)
	Before Treatment	A Week After Treatment	
Carbosulfan	8	1	87.50
Acephate	13	6	53.85
Cypermethrin	7	3	57.14
Control	6	6	no reduction
	T-test: 5.3863, df = 97, *P* = 5.026e-07		

Overall, 34 out of 98 coconut trees were recorded as RPW-infested trees in Week 1 (Figure 7), with 23 trees recorded as severe based on the RPW acoustic activity inside the hos, while the remaining 11 trees were categorized as low RPW acoustic activity. In between Week 1 and Week 2, chemical treatment was applied to each infested tree. In Week 2, 55.88% reduction was recorded in the study site, while further reduction was recorded in Week 3 and Week 4 with only 12 trees were recorded positive for RPW acoustic activity. The chemical treatments proven as effective, as only two coconut trees still detected as high RPW acoustic activity. Subsequently, no more severe-infested tree detected and only 10 trees with low acoustic activity of RPW. The observation continued until Week 6 and Week 7 where all infested trees recorded were free from RPW infestation based on the absence of RPW larval activities inside the host. Unless the target insects are vectors of viruses or other harmful infections, immediate action of insecticides is not necessary to protect crops. There are certain pesticides that causes targeted pest to stop feeding long before it is killed (Martinez et al. 2014). The larvae of RPW in this instance were able to continue feed, based on the acoustic detection method, even if they eventually die.

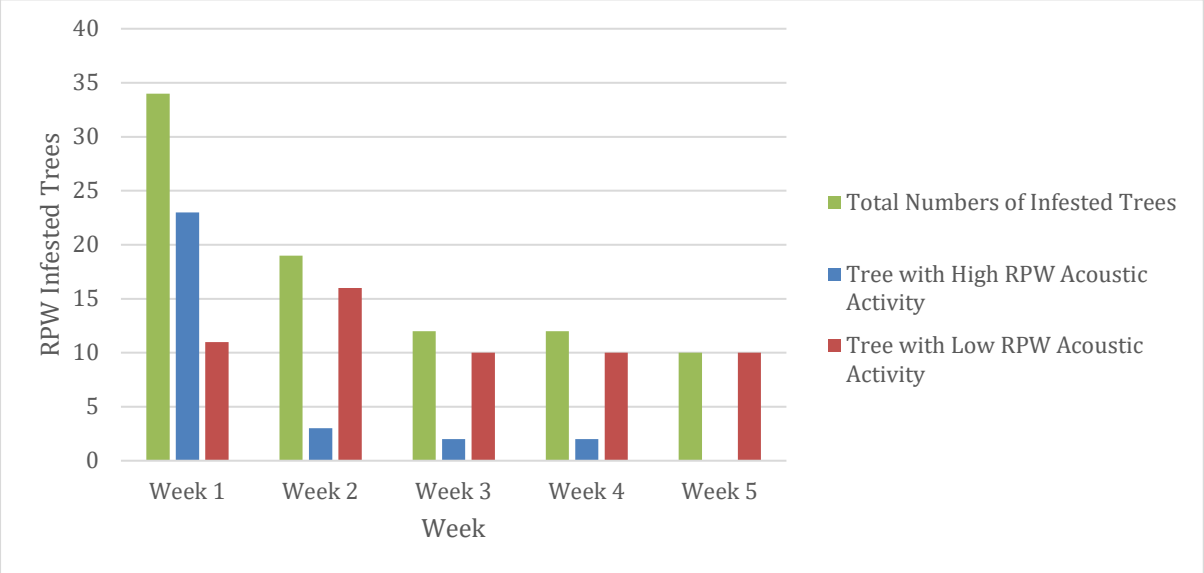

Figure 7. Reduction of RPW-infested coconut trees before treatment (Week 1) and after the chemical treatment (Week 2) until all infested trees were free from RPW (Week 6 and 7)

CONCLUSION

Chemical pesticide treatment is always needed to control pest infestation since this method is the fastest and most effective way to ensure all the pests inside the host plant are killed. Thus, further study on the most effective chemical pesticide in dealing with RPW was conducted in this research. Carbosulfan recorded to be the most effective insecticide to cause the largest lethal effect on RPW population inside the host plant as 87.5% controlled after one week of treatment. Therefore, application of carbosulfan at 60g is recommended to give good control of RPW, and could be one of the component ~~in~~ Integrated Management of RPW. From this study, we would suggest an in-depth study with more sample palms and more uniform experimental materials in a controlled environment. In the proposed of future study, same aged healthy coconut/ oil palms should be artificially infested with similar number of red palm weevils of each life stage, and should be treated with selected chemicals. By doing so, a better and more comprehensive data could be gathered to evaluate the chemical control of RPW, as part of our national integrated RPW management program.

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AUTHORS DECLARATIONS

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Conflict of Interest
The authors declare that they have no conflict of interest.

Ethics Declarations
No ethical issue required for this research

Data Availability Statement
My manuscript has no associated data

Authors' Contributions
Azlina Zakaria (AZ), Mohamad Haris Hussain (MHH) and Johari Jalinas (JJ) conceived this research and experiments, performed experiments and interpreted the data and analysis of data. AZ, Meor Badli Shah Ahmad Rafie (MBSAR), Samsudin Amit (SA), MHH, JJ and Idris Ab Ghani (IAB) wrote the paper and participated in the revisions of it. All authors read and approved the final manuscript.

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