EFFICACY OF ROOT ABSORPTION TECHNIQUE OF METHAMIDOPHOS AND MONOCROTOPHOS TO CONTROL *METISA PLANA* WALKER (LEPIDOPTERA: PSYCHIDAE) IN OIL PALM PLANTATIONS.

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ABSTRACT: *A field trial was carried out to evaluate the efficacy of commonly used systemic insecticides, methamidophos and monocrotophos and applied via root absorption techniques for controlling bagworm, Metisa plana in oil palm plantations. The study was conducted on young oil palms (5 years old) which heavily infested by the bagworm. Three treatments or dilution rates (10 ml undiluted per palm, 10 ml diluted in 15 ml of water per palm, and 10 ml diluted in 30 ml of water per palm) for each insecticide were applied. A control plot that was treated only with water without any treatment was included for comparison. The results of the study showed as early as 3 days after treatment (DAT), the larval population of* M. plana *was reduced by 41% to 95%, while infestation in the control palms increased by 15%. At 14 DAT, the pest population had declined at 83% in all the treatments. These reductions were highly significant as compared to the control. At 30 DAT, the pest population was reduced by up to 90% and below than the threshold level of 10 lives larvae per frond in all treatments, demonstrating the effectiveness of the insecticides and application technique. Without requiring sophisticated equipment and no harm to the palm as well as less expose of chemical to the environment this technique would be a good alternative and convenient method for controlling bagworm in oil palm plantations.*

Keywords: bagworm, oil palm, trunk injection, systemic insecticide

1. INTRODUCTION

The bagworm, *Metisa plana*, is one of the most serious leaf defoliators of oil palm in Malaysia. Such pest infestations are common in the Northern Region (Perak) and Southern Region (Johore) in oil palm plantations of Peninsular Malaysia [9, 14]. Two types of chemical application technique are commonly used in controlling bagworm infestation. Systemic insecticides are popularly applied via trunk injection method [12, 14, 17, 26] and contact insecticides are sprayed on foliar of infested palm [3- 4, 8, 22].

The systemic insecticides applied by trunk injection method is more suitable for controlling bagworms in mature oil palms while foliar spraying of contact insecticides is widely employed in young oil palms of below 6 years [25]. However, spraying of contact insecticides has been found detrimental to non-target organisms including beneficial insects such as pollinators and parasitoids [21]. While injecting a chemical into the palm trunk over a long period could cause permanent injury to the stem. Although trunk injection obviates the risk of spray contamination of the environment, the holes provided entries to pathogens and weakening of the palm and subsequently affect the yield of the palms [15, 21].

Like trunk injection, root absorption method is designed to control only the target pests, but it has an added advantage of not damaging the trunk. The root applications of systemic insecticides were developed by researchers to overcome the limitation of trunks injection and foliar application in controlling leaf-eating caterpillars. By this technique, the insecticide is contained in a small container from which a tube extends and is fitted over a cut end of a root, and the material is fed by gravity [10]. The technique has been studied in Indonesia for the control of several pest species which are mainly leaf-eating caterpillars [6].

In India, this technique has been recommended and widely used in coconut along with other conventional technique such trunk injection and spraying techniques to control the black-headed caterpillar, *Opisina arenosella*, and red palm weevil, *Rhynchophorus ferrugineus* [2, 16]. Application of systemic insecticides, through this method, was effective against *Xylastodoris luteolus*, the royal palm bug for up to two seasons [11]. In Florida, thousand of royal palms were protected from pest damage when systemic insecticides were applied through root absorption method [10].The root absorption technique is reported safe to the palm as there is no injury to the stem and can be applied at any palm age. The technique is safe to non-target organisms as well as no spraying application required [5, 21, 24]. Therefore, the efficacy study of root absorption technique as an alternative control for bagworm in oil palm plantation is extremely important. The research was conducted to determine the field efficacy of commonly used systemic insecticide, methamidophos and monocrotophos. The operational productivity and cost of control were calculated. Subsequently, the advantages and disadvantages of this technique were sorted

2. MATERIALS AND METHODS

Study Area and Experimental Design

The efficacy of monocrotophos and methamidophos applied through root feeding was evaluated at a trial laid out in FELDA Gunung Besout 3, Sungkai district in the state of Perak, Malaysia on 4-year-old oil palms. The population of bagworm, M. plana, in this location was found to be discrete, non- overlapping generation of the bagworm.

This experiment was carried out with six different treatment rates of methamidophos and monocrotophos in three replicates. One replicate consisted of three plots with 5 palms per plot. A control plot was untreated with insecticide, but instead, the palm's trunk was injected with 40 ml of water (Table 1). Since the bagworm

population was not uniformly distributed in the field, the trial was divided into 4 blocks based on their infestation severity. The trial was laid out in a Randomized Complete Block Design (RCBD). based on their infestation severity. The trial was laid out in a Randomized Complete Block Design (RCBD).

Table 1: Treatments and Dosages

Treatment	Active Ingredient (a.i.)	Dosage (insecticide + water)
T1	Methamidophos	10 ml + 0 ml
T2	Methamidophos	10 ml + 15 ml
T3	Methamidophos	10 ml + 30 ml
T4	Monocrotophos	10 ml + 0 ml
T5	Monocrotophos	10 ml + 15 ml
T6	Monocrotophos	10 ml + 30 ml
T7	Control (untreated)	0 ml + 40 ml

Assessment of Bagworm Population

A pre-treatment census of bagworm larvae population was carried out prior to insecticide application. Efficacy of the treatment was assessed by examining the pest population at 3, 7, 14 and 30 days after treatment (DAT). One middle frond of each selected palm was removed and the number of bagworm larvae on all the pinnae was counted and recorded. The results were analysed using the Statistical Package for Social Sciences (SPSS) for Windows Version 19.5. Differences in a mean number of bagworms of the treatments at various sampling days were analysed using Two-Way ANOVA. Significant F values were further analysed using Tukey's multiple mean comparisons to isolate the most effective treatment. Performances of different dosages of methamidophos and monocrotophos against the pest were evaluated. Operational costs of these treatments were also estimated.

Root Selection and Application of Insecticides

The procedure of this technique in the field followed the descriptions of [21] and [24]. A fresh and live primary root of approximately 0.6 cm in diameter and 20 cm long, brown to blackish brown in colour was selected for the treatment. Only one root was selected for each palm. The required quantity of insecticide and water was measured into a 6 cm x 15 cm polyethylene bag. The identified root was given a slanted cut and immersed in the solution for absorption.

Finally, the bag was fastened tightly with parafilm and laid down in the root's original position. For observation, the hole was left open until all the insecticide was completely absorbed by the root. If less than 10% of the chemicals were absorbed in 24 hours, a new root was selected. Two workers were required to carry out the operation, one to search and prepare the root by digging a hole within the root zone, and another to prepare the insecticide accordingly for the application. The time consumed was recorded to estimate the productivity of the operators.

Precautionary and Safety Measures

Since the insecticides, methamidophos and monocrotophos, are classified under the group of HTP (highly toxic pesticides) which are normally allowed for application via trunk injection, special precautionary and safety measures were adopted in the above trial during chemical handling and application. The handling and application of methamidophos and monocrotophos was entrusted to only well-trained applicators that abide by all the safety measures given. Operators were compulsory to wear personal protection equipment (PPE) such as mask, gloves and goggle. Unprotected workers were kept out of the treated areas for 48 hours.

3. RESULTS AND DISCUSSION

Effectiveness of Treatments

All insecticides applied in the treatments were effective in controlling *M. plana*. The mean number of *M. plana* larvae from each treatment was significantly different ($F= 2.436$, $P< 0.05$) on different days of assessment (Table 2). According to [24], the efficacy of root absorption is very high, reaching 95% to 100 %. The results of this study showed comparable effectiveness with 100% population reduction below the threshold level of 10 larvae per frond (LPF) a month after treatment. The population of *M. plana* was reduced by 41% to 95% in all the treatments as early as 3 DAT while the population of the pest in the control plot increased by 15%. The Tukey's multiple comparison tests showed no significant difference ($P> 0.05$) of *M. plana* population in all the treatments during pre-treatment. However, they were significantly different in treatments T1 to T6 compared to those of the control plot as early as 3 DAT and thereafter.

At 7 DAT, all chemical treatments showed a high reduction of the bagworm population in the range of 66% to 98%. A slight reduction (2.81%) was observed in the control plot probably due to the effect of biotic and abiotic factors such as rainfall, natural enemies, etc. At this time, the *M. plana* population in the control plots was still high (46 LPF) compared to the population in the treatment plots at and below 17 LPF.

At 30 DAT, all insecticides showed high efficacy against the pest. The pest population was reduced by 90% - 100% in all the treatments, demonstrating the effectiveness of the chemicals and application technique. As for the control plot, the pest population was reduced by 49%, from 47 LPF to 24 LPF. The mortality of the pest in the control plot was probably related to intraspecies competition among individuals for food and space. This type of situation had been reported to occur naturally in bagworm populations especially during high infestation levels [19]. The result at 30 DAT showed that up to this period, the bagworm, *M. plana*, was susceptible to both insecticides.

Population increase in the control plot was very much attributed to asynchronous hatching of eggs and migration of bagworm larvae by the 'ballooning' effect from neighbouring untreated palms. The asynchronous hatching of eggs occurred naturally in the field especially during high pest population levels [9]. 'Ballooning' is the process of migration of larvae suspended from silken threads and wind dispersed [19-20] to new areas. The result of this study also indicated that methamidophos was more effective in controlling *M.* plana than monocrotophos (Table 3), although the population reduction was not statistically different ($F= 2.136$, $P>0.05$). Methamidophos treatments were more effective than monocrotophos treatments in reducing the pest population by 5.52% - 31.56% at 7 DAT, and by 3.61% – 16.66% at 14 DAT. [4] reported that methamidophos was more superior than monocrotophos in controlling leaf-eating caterpillars other than bagworms in oil palm plantations. Methamidophos was also found to be more effective than

monocrotophos in controlling the leaf-eating pest, *Euprostema elaeasa*, in Central and South America [24].

According to [5], methamidophos and monocrotophos were better absorbed by palm roots compared to other systemic insecticides, consequently they were very effective in controlling leaf eating pests in coconut and oil palm plantations. The efficacy of these chemicals was very much dependent on the type of formulation and dilution rate. However, no significant difference in efficacy was shown by the different dilution rates of the respective insecticide treatments, although methamidophos diluted with 30 ml water achieved the earliest 100% mortality at 14 DAT. Monocrotophos diluted with 10 ml water achieved 100% mortality only at 30 DAT.

Table 2: Efficacy of treatments administered through root absorption on the larval population of *M. plana*

Treatments	Mean pest population (larval per frond)			
	Pre	3 DAT	7 DAT	30 DAT
T1	113.3 a	30.6 a *(72.9 %)*	12.6 a *(88.82 %)*	2.6 a *(97.64 %)*
T2	67.3 a	22.6 a *(66.3 %)*	8.6 a *(87.12 %)*	2.0 a *(97.02 %)*
T3	74.6 a	3.3 a *(95.5 %)*	1.3 a *(98.21 %)*	0.0 a *(100 %)*
T4	92.6 a	10.6 a *(88.4 %)*	17.3 a *(81.29 %)*	2.6 a *(97.11 %)*
T5	58.0 a	34.0 a *(41.3 %)*	10.6 a *(81.60 %)*	0.0 a *(100 %)*
T6	44.0 a	10.0 a *(77.2 %)*	14.6 a *(66.65 %)*	4.3 a *(90.15 %)*
T7	47.3 a	54.6 b *(+15.5 %)*	46.0 b *(2.8 %)*	24.0 b *(49.2 %)*

Means within a column followed by the same letters are not significantly different (P>0.05) by Tukey's test; DAT = Days after treatment; Numbers in the column are % reduction of *M. plana* population after treatment

Table 3: Mean numbers of *Metisa plana* larvae surviving after 7 and 14 days after treatment

Treatment	Mean number of larvae at 14 DAT		
	Undiluted	+ 15 ml water	+ 30 ml water
Metha (A)	4.6a *(95.87)*	0.6a *(99.00)*	0.0a *(100.0)*
Mono (B)	10.6a *(88.4)*	2.6a *(95.3)*	7.3a *(83.3)*
% reduction A against B	+ 7.3	+ 3.6	+ 16.6

Means within a column followed by the same letter are not significantly different (P>0.05) by Tukey's test; Methamidophos (A); Monocrotophos (B)

Based on findings by [15], methamidophos was more efficiently translocated to the leaf than monocrotophos. This property has been also proven scientifically by [1] who found that more residues of methamidophos, of up to 66% more than the content of monocrotophos, were detected in the foliage receiving the same chemical dosage. A relatively higher polarity of methamidophos [1, 15, 19] was used to explain its enhanced translocation in the plant and subsequently provided better control against the leaf-eating caterpillars. These findings could thus explain the more efficacious results of methamidophos in this study.

Operational Productivity and Cost

Time and cost incurred for the preparation and treatment of each palm tree were recorded to determine worker productivity of the root absorption technique. It was found that the mean time taken to prepare each palm was 5.07± 0.88 minutes (Table 4). Therefore, the two workers in this study were able to treat about 90 palms in a day. However, the number of treated palms depended considerably on the soil type, the topography of the plantation and skill of the worker. [21] estimated that two workers could treat 80 to 100 palms per day under good supervision. [13] and [24] estimated the productivity of the technique by a trained worker to be 2 to 3 minutes per palm. Depending on the type of soil, the workers could cover just over 1 ha or about 130 palms a day. In general, the root absorption technique was time-consuming, resulting in low coverage. According to a trial by [7] investigating the efficacy of trunk injection with systemic insecticides, a team was able to treat 360 palms a day, or at 1.30 ± 0.15 minute per palm. By the same study for comparison, ground spraying of insecticide on the 5-year-old palms took 4.5 hours per ha or 2.13 minutes per palm [8].

Table 4: Productivity of root absorption technique

Site of study (Replicate)	Time spent for preparation of palm (Mean ± s.d)
A	5.25 ±1.10 minutes
B	4.41 ± 0.59 minutes
C	4.06 ± 0.94 minutes
Mean	5.07± 0.88 minutes

Table 5: Cost estimation root absorption technique

Item	Amount / ha	Cost per unit	Cost / ha
Chemical	1.36 llitre	RM 30.00 / liter	RM 40.80
Plastic bag	136 units	RM 0.10 / bag	RM 13.60
Sealing tape	1 box	RM 2.50	RM 2.50
Manpower	2 workers	RM 15.00	RM 30.00
Total cost per hectare		RM 86.90	

Notes: RM = Ringgit Malaysia (1 $USD = RM 3.80, 2016); ha = hectare

[18] acknowledged the potential of the root absorption technique despite it being slow especially when many palms required treatment.The estimated cost of the root absorption technique in this study is shown in Table 5. Treatment of one hectare of oil palm (136 palms) would cost RM 86.90 or RM 0.60 per palm. This cost is lower compared to that of trunk injection, estimated at RM95.00 per ha or RM 0.70 per palm [8]. The higher cost of

trunk injection is mainly due to maintenance of the drilling machine, injector gun and petrol.

4. CONCLUSIONS

The root application technique of systemic insecticides was effective in controlling bagworm, *M. plana* by bringing its population level to below the injury threshold level from a single treatment of methamidophos and monocrotophos treatment. Both of the insecticides tested were well trans-located from the roots to the foliage. The root absorption method has good potential to overcome the difficulties in treating oil palms by spraying and trunk injection techniques. However, on the safety aspects of root absorption technique, there is room for improvement in the handling and delivery of the chemical. The polyethylene bag for containing the insecticide should be improved or changed to a more suitable material. It should be specially produced for easier and faster filling of chemical and it should not leak to contaminate the soil and environment. Finally, workers must be well trained to achieve high productivity to make this technique more cost-effective.

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6. REFERENCES

[1] Ang, B. N., Cheah, U. B. and Chew, P. S. Efficacy and residues of monocrotophos and methamidophos following trunk injection for the control of *Darna trima* (Moore) (Lep: Limacodidae), a leaf-eating caterpillar of oil palm. *The Planter, Kuala Lumpur, 74 (867):*303- 316. (1998).

[2] Anon, www.aphorticulture.com. 2009

[3] Basri, M. W., Abdul Halim, H and Zulkipli, M. Bagworms (Lepidoptera: Psychidae) of Oil Palms in Malaysia. *PORIM Occasional Paper 23:* 1-23. (1988).

[4] Chung, G.F. *Spraying and trunk injection of oil palm for pest problem.* Persidangan Kebangsaan Kelapa Sawit Minyak Sawit Perkembangan Masakini. pp 500 – 525. (1989).

[5] Ginting, C. U. and Desmier de Chenon, R. *Teknik infuse akar untuk melindungi kebun benih sepanjang tahun*. Seminar Proteksi Tanaman Kelapa, LPP Bogor, Indonesia. (1985).

[6] Ginting, C.U. and Purba, A. *Kemungkinan pengendalian hama pada tanaman perkebunan dengan infuse akar* in Sinuraya *et al*. Root absorption treatment to control oil palm pests in North Sumatra, Indonesia. *PORIM*. (1989).

[7] Hasber, S., Che Salmah, M. R. Noor Hisham, H., Sukri, T. I, Cik Mohd Rizuan, Z. A. and Abu Hassan, A Efficacy of Trunk Injection Technique of Systemic Insecticide Against Bagworms on Oil Palm. Advances in Enviromental Biology 9(27). 128 - 133. (2015a).

[8] Hasber, S., Che Salmah, M. R., Abu Hassan, A. Salman, A. A Efficacy of insecticide and bioinsecticide ground sprays to control Metisa plana Walker (Lepidoptera: Psychidae) in oil plam plantations. *Tropical Life Sciences Research 26(2): 73-83.* (2015b).

[9] Ho, C.T. Ecological Studies of *Pteroma pendula* Joannis and *Metisa plana* Walker (Lepidoptera: Psycidae) Towards Improved Integrated Management of Pest Infestation in Oil Palm. Ph.D. thesis. Universiti Putra Malaysia. (2002).

[10] Howard, F. W., Moore, D., Giblin-Davis, R.M. and Abad, R.G. Insects on Palms. CABI Publishing United Kingdom. 400 pp. (2001).

[11] Howard, F. W. and Stopek, A. Control of royal palm bug, *Xylastodoris luteolus* (Hemiptera: Thaumastocoridae) with imidaclorid: a refinement in the method. *Palms* 43: 174-174. (1999).

[12]. Hutauruk, C. H. dan Sipayung, A. *Development of trunk injection of systemic insecticides against Setora nitens and Thosea asigna on oil palm in North Sumatera*. Proceedings Plant Protechtion Conference, Kuala Lumpur. pp 265- 278. (1978)

[13] Mariau, D. and Gently, P. *Methode de luttte contre leas ravageurs du palmier a huile et du cocotier par absorption radiculaire* in Turner, P.D. and Gillbanks, R.A. (2003). *Oil Palm Cultivation and Management – Second Edition*. The Incorporated of Planters, Kuala Lumpur, Malaysia. (1992).

[14] Mutuuraman, M. Trunk injection of undiluted insecticides - A method to control coconut red palm weevil, *Rhynchophorus ferrugineus* Fab. *Indian Coconut Journal* 15: 12-14. (1984)

[15] Ng, K. Y. and Chong, Y. W. Studies on some aspects of trunk injection technique for the control of *Darna trima* in oil palm. Malay Peninsular Agric. Ass. Yr. Book, pp 39-45. (1982).

[16] Noor Hisham, H. 2007 Annual Report, FELDA Agricultural Services Sdn. Bhd. 42 pages. (2007).

[17] Ooi, P. A. C., Yunus, A., Goh, K. G. dan Balasubramaniam, A. *Control of the coconut leaf moth, Artona catoxantha Hamps by trunk injection technique*. Malaysian Agricultural Journal 50. pp 157 – 158. (1975)

[18] Philippe, R., Mariau, D., Bernard, D., Quilici, S. and Nguyen-Ban, J. Chapter 2, Rational Chemical Pest Control, pp 9-46. (1999).

[19] Rhainds, M. Reproductive success of bagworms, *Oeketicus kirbyi* (Guilding) and *Metisa plana* (Walker) (Lepidoptera). Ph.D. thesis, Simon Fraser University. (1999).

[20] Rhainds, M. and Ho, C. H. Size dependent reproductive output of female bagworms (Lepidoptera: Psychidae): implications for inter-generational variations of population density. *Appl. Entomol. Zool. 37 (3): 357-364*. (2002).

[21] Sinuraya, I., Desmier de Chenon, R., Tamba, W. and Sitepu, RRoot absorption treatment to control oil palm pests in North Sumatra, Indonesia. PORIM International Palm Oil Development Conference, Kuala Lumpur, pp 274-284. . (1989).

[22]. Syed, A. R. and Salleh, a. (1991). Management of insects pests of oil palm in PT PP London Sumatra Indonesia Plantations In Sumatera, Indonesia. In Proceedings PORIM International Palm Oil Conference. Progress, Prospects & Challenges Towards the 21st century. Kuala Lumpur. pp 451-457.

[23] Tomlin, C. D. S. The Pesticides Manual. British Crop Protection Council and the Royal Society of Chemistry. (1994).
[24] Turner, P.D. and Gillbanks, R.A. Oil Palm Cultivation and Management – Second Edition. The Incorporated Society of Planters, Kuala Lumpur, Malaysia. (2003).
[25] Wood, B.J. Pest of Oil palms in Malaysia and their Control. Incorporated Society of Planters. 204pp. (1968).
[26] Yap, T. H. *The intelligent management of Lepidoptera leaf eaters in mature oil palm by trunk injection (A review of principles)*. The Planter; Kuala Lumpur, 76 (887): pp 99-107. 2000

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