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Evaluation of Acephate and Dimehypo Against the Bagworm, *Dapula (Clania) tertia* by Trunk Injection

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A field trial was conducted to evaluate the efficacy of two insecticides to control a large species of bagworm, i.e. Dapula (Clania) tertia, *by trunk injection. The two insecticides evaluated were acephate (in two formulations, i.e. as a soluble powder and a liquid) and dimehypo (liquid formulation only). Acephate was tested in two rates for soluble powder formulation (7.5 g a.i. and 9.4 g a.i. per palm) and two rates for liquid formulation (6 g a.i. and 8 g a.i. per palm). Dimehypo was also tested at two rates, i.e. 6 g a.i. and 8 g a.i. per palm. Post-treatment assessment of live bagworm larvae population was carried out at 7, 14, 21 and 28 days after the trunk injection treatments. The treatments of acephate soluble powder formulation at 7.5 g a.i. per palm and dimehypo at 6 g a.i. per palm were least effective as these two treatments recorded the highest number of larvae at the end of the trial compared to the other treatments. Liquid formulation of acephate at 6 g a.i. per palm and dimehypo at 8 g a.i. per palm caused some reduction in the population of bagworm larvae, but the desired maximum kill was not achieved. Both soluble powder and liquid formulations of acephate at the rate of 9.4 g a.i. per palm and 8 g a.i. per palm respectively were the best amongst the treatments, and resulted in fast and complete control of the bagworm larvae population at 21 days after treatment.*

Keywords*: Bagworm,* Dapula (Clania) tertia, *acephate, dimehypo, trunk injection*

Indonesia is currently the world's largest producer of palm oil in the world. Hence, oil palm cultivation has expanded rapidly in various parts of Indonesia, particularly in Kalimantan. This rapid increase in oil palm cultivation inevitably provide opportunities for various pests to establish and proliferate, subsequently causing outbreaks. These pests include one group of leaf eating caterpillars, specifically bagworms (order: Lepidoptera; family: Psychidae), which are amongst the most destructive pests of oil palm.

Norman *et al*. (1994) reported, that two genera and eight species of bagworms are associated with oil palm in Malaysia. However, three species of bagworms (from the family Psychidae) namely, *Metisa plana*, *Pteroma pendula* and *Mahasena corbetti* are the most common leaf-eating pests found in oil palm plantations (Wood, 1968; Basri *et al.*, 1988; Sudharto *et al*., 2005; Norman & Basri, 2007). Apart from the aforementioned three most common bagworm species, *Dapula* (*Clania*) *tertia* has infested oil palm in the recent years in several parts of Indonesia. The name of this species has been revised from *Clania tertia* and now given as *Dapula* (*Clania*) *tertia* (Wood, pers. comm. 2019). This species has been known as a major leaf-eating pest of *Acacia mangium* (Rozziansha *et al*., 2012). An attack by *Dapula* (*Clania*) *tertia* was first noted in South Sumatra in early 2004 (Sumantri

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et al., 2011; Wood & Norman, 2019a). However, in the recent years, outbreaks of *Dapula* (*Clania*) *tertia* caused significant damage to oil palm in several provinces of Indonesia (Rozziansha, *et al*., 2011 & 2012; Andreas *et al*., 2013; Balasubramaniam & Chung, 2013; Wood & Norman, 2019b).

Dapula (*Clania) tertia* larvae are larger compared to the larvae of other common bagworm species such as *Metisa plana* and *Pteroma pendula*. The larvae of *Dapula (Clania) tertia* in the early stage feed by "scraping" the upper surface of the leaf; the scraped portion dries out and then forms a hole (*Figure 1*).

The larvae in the final stages feed on the leaf tissue from the margins (*Figure 2*). The pupae of *Dapula (Clania) tertia* were found in large clusters at the fork of the branches of *Acacia mangium* grown as shade trees, in the plantation where the trial reported in this paper was carried out (*Figure 3*).

Bagworms are categorised as occasional pests (Chung *et al*.,1995). However, under favourable conditions, their population buildup can be so rapid and cause extensive defoliation of the oil palm which in turn could reduce the oil palm yield significantly up to two years. The crop loss caused by bagworms have been reported by the following researchers:

- Wood *et al*. (1973) estimated an average of 30 per cent crop decline over a period of two years subsequent to the pest outbreak.
- Liau (1987) reported that severe defoliation by *Mahasena corbetti* resulted in crop losses of 40-50 per cent in the two subsequent years.
- Basri (1993) reported that, a moderate

Figure 1 Young larvae of Dapula (Clania) tertia *feeding by scrapping the upper surface of the leaf tissue.*

Figure 2 Large larvae of Dapula (Clania) tertia *feeding on the leaf tissue from the margins*

Figure 3 Cluster of Dapula (Clania) tertia *pupae at the fork of* Acacia mangium *branches*

defoliation of about 10-13 per cent caused by *Metisa plana* resulted in 40 per cent yield reduction.

- Balasubramaniam and Chung (2013) reported that, the effect of heavy defoliation by *Dapula (Clania) tertia* caused 35 per cent yield loss in the subsequent year after the outbreak.

Application of systemic insecticides through trunk injection technique is one of the effective methods used to control bagworm outbreak in oil palm plantations. This mode of chemical control has been proven to be effective because it is a fast means of control and is suitable for large scale pest control operations. Furthermore, chemical control using insecticides is accepted as a practical component in integrated pest management (IPM) packages (Chung, 1998). Insecticides are applied in IPM only when an economic threshold level (ETL) of the pest population is exceeded. For bagworms, without establishing ETLs, action thresholds have been suggested by Wood (1968) to be 10 larvae per frond for the smaller species (e.g. *Metisa plana* and *Pteroma pendula*) and five larvae per frond for the larger species (e.g. *Mahasena corbetti*). Andreas *et al*. (2013) fixed the action threshold at five larvae per frond for *Dapula (Clania) tertia*.

Several methods and related equipment are used for application of insecticides to suppress bagworm outbreaks. Ground application of insecticides, using conventional knapsack sprayer, knapsack mistblower and tractor mounted mistblower, is employed in immature and young mature oil palm areas to suppress bagworm outbreaks. For mature areas with tall palms (i.e. more than five years after planting), trunk injection using systemic insecticides is utilised as it is a practical and effective method for control of bagworms in large scale operations (Wood *et al*., 1974; Hasber *et al*., 2015). Yap (2005) suggested that, for effective control when an outbreak occurs, suitable efficient techniques and methodologies must be taken into consideration. Chung (1989) reported that current application techniques (i.e. spraying and trunk injection) are adequate to provide effective control of the leaf-eating pests. However, application of systemic insecticides through trunk injection technique is more environment-friendly because only the target leaf-eating pests are killed without harming the non-target organisms, particularly the natural enemies of the leaf-eaters (Chung, 1998; Teh, 1996).

The following trial was aimed to evaluate the efficacy as well as to determine the effective rate of commercial formulations of acephate and dimehypo by trunk injection for control of *Dapula (Clania) tertia*, in six-year-old oil palm plantings.

METHODS AND MATERIALS

This field trial was initiated on six-year-old oil palm planting near Sampit, Central Kalimantan which experienced a high infestation of *Dapula (Clania) tertia*. The following six treatments were evaluated in comparison with an untreated control:

- two rates of acephate 75 per cent soluble powder formulation i.e. 10 g and 12.5 g per palm,
- two rates of acephate 40 per cent liquid formulation i.e. 15 ml and 20 ml per palm, and
- two rates of dimehypo 40 per cent liquid formulation i.e. 15 ml and 20 ml per palm

The trial was laid down in a randomised complete block design (RCBD) with three replicates per treatment. Each plot consisted

of three rows of twelve palms. Six palms in the central row of each plot were marked for pre-treatment and post treatment assessments. A bagworm infested frond was cut from each palm at every assessment for counting the bagworm larvae. The pre-treatment assessment was undertaken just prior to the treatment application followed by post treatment assessments which were carried out at 7, 14, 21 and 28 days after treatment. The number of live bagworm larvae was also counted and recorded during each assessment.

The trunk injection treatment was carried out using a chain saw adapted drill which was used to drill holes close to the base of the trunk at about 0.5 m above the ground at an angle of 45° (to the horizontal ground surface). For convenient and easy administration of the insecticide into the drilled holes, the acephate soluble powder was mixed with water at 1:1 ratio and thoroughly stirred to obtain a colloidal solution. This colloidal solution of acephate was then injected into the drilled holes using a plastic syringe. In contrast, the liquid formulations of acephate and dimehypo were injected neat, directly into the drilled holes using plastic syringe. Immediately after administering the insecticides, the holes in both the acephate and dimehypo treatments were plugged with mud. The treatments were applied when the bagworms were actively feeding during their early larval instar stage.

RESULTS

Results from the treatments carried out are summarised in *Table 1*. The post-treatment results showed that, acephate 75 per cent soluble powder formulation at 12.5 g per palm and acephate 40 per cent liquid formulation at 20 ml per palm resulted in the fastest reduction of the larvae population. Post-treatment assessments of the aforementioned treatment at 14, 21 and 28 DAT (days after treatment) showed the mean larvae count was significantly lower than the other treatments. Furthermore, both the above-mentioned treatments also provided almost complete reduction of the larvae population at 21 DAT. Both the lower rate of acephate 75 per cent soluble powder formulation (at 10 g per palm) and acephate 40 per cent liquid formulation (at 15 ml/palm) as well as both the lower and higher rate of dimehypo 40 per cent liquid formulation (at 15 ml and 20 ml/palm) gave some control by reducing the bagworm population at 28 DAT. However, since all the bagworm larvae were not eliminated, the small numbers left behind may cause re-infestation. The treatments, acephate 75 per cent soluble powder formulation at 10 g per palm and dimehypo 40 per cent liquid formulation at 15 ml per palm were found to be the least effective amongst the insecticide treatments. Hence, between the two systemic insecticides tested (acephate *vs* dimehypo), the trial results clearly demonstrated that the powder formulation of acephate at 12.5 g per palm and soluble liquid formulation of acephate at 20 ml per palm exhibited the fastest and most effective control of *Dapula* (*Clania) tertia*. The control treatment registered some decrease in larvae population in the post-treatment assessments from 7 DAT up to 28 DAT, possibly due to natural mortality and transition to the pupae stage. But, during the span of the post-treatment assessments, the mean number of larvae per frond in the control treatment remained relatively higher than the other treatments. At 21 DAT and 28 DAT, the larvae population in the control treatment was significantly higher than all the other treatments.

DISCUSSION

Chung *et al.* (1995) reported that spraying the canopy of the immature oil palm with the

TABLE 1
EFFECTS OF ACEPHATE AND DIMEHYPO TREATMENTS APPLIED BY TRUNK INJECTION AGAINST THE LARVAE POPULATION OF *DAPULA* (*CLANIA*) *TERTIA*

Treatment (active ingredient)	*Product formulation*	*G ai/palm*	*Product in ml/g per palm*	*Mean number of larvae per frond*				
				Pre-treatment assessment	*Post-treatment assessment*			
					7 DAT	*14 DAT*	*21 DAT*	*28 DAT*
Acephate	75% SP	7.5	10 g	176.00a	122.67abc	101.33ab	51.00b	27.33b
Acephate	75% SP	9.4	12.5 g	196.33a	51.33e	23.67d	0.00c	0.00d
Acephate	40% SL	6	15ml	175.33a	141.67ab	96.33ab	47.33b	22.67bc
Acephate	40% SL	8	20ml	171.33a	60.67de	22.00d	1.00c	0.00d
Dimehypo	40% SL	6	15ml	164.67a	115.67bc	81.67bc	54.33b	36.33b
Dimehypo	40% SL	8	20ml	180.67a	92.00cd	52.33cd	34.00b	12.33cd
Untreated control	-	-	-	178.67a	156.67a	126.33a	117.33a	98.33a

Notes:
SP: Soluble powder
SL: Soluble liquid
DAT: Days after treatment
Mean values with different alphabets in the column are significantly different based on LSD test ($p>0.05$)

insecticide cypermethrin is the most effective way to control common bagworm species due to adequate spray coverage of the young mature palm canopies. However, adequate spray coverage of the taller mature oil palm with insecticide is not possible using mechanical spray equipment. For the mature oil palm (aged 6 years and above) trunk injection with systemic insecticides such as monocrotophos, methamidophos and acephate at appropriate rates was reported to be highly effective against bagworms such as *Metisa plana* (Wood *et al*., 1974; Ng & Chong, 1982; Chung, 1989; Hasber & Noor Hisham, 2012; Hasber *et al*., 2015). Since the insecticides monocrotophos and methamidophos are not available in Indonesia, this study has proven that acephate (which is an organophosphate insecticide and available in Indonesia) is a viable option for controlling bagworm outbreak through trunk injection. The acephate rate of 7.5 g a.i. per palm was recommended by Chung (1989) to be effective against the smaller bagworm species such as *Metisa plana* and *Pteroma pendula*. But, the results from this study showed that the aforementioned recommended rate was not sufficient for complete control of larger species of bagworm such as *Dapula (Clania) tertia.*

Results from the study have shown that both the powder and liquid formulation of acephate at 9.4 g a.i. per palm and 8 g a.i. per palm respectively are the optimal rates to control large species of bagworms such as *Dapula* (*Clania) tertia via* trunk injection. Utilisation of acephate at the aforementioned rates gave complete control of the leaf-eating pest in about 21 days after commencement of treatment and was more effective than using dimehypo for trunk injection (at the rate of 6 g a.i./palm and 8 g a.i./palm). This current study also confirmed the earlier findings by Balasubramaniam and George (2016) that, acephate 75 per cent soluble powder formulation at 12.5 g per palm (or, 9.4 g a.i./ palm) is effective to control *Dapula* (*Clania*) *tertia*. There had also been some skepticism on the use and efficacy of soluble acephate powder in the form of colloidal solution for trunk injection. This study has disproved the aforementioned skepticism.

The study has also elicited that when undertaking bagworm control using insecticide on a commercial scale, insufficient insecticide rate will result in incomplete control of the pest, and therefore, will give rise to the possibility of re-infestation. The aforementioned will entail increased pest control rounds which will inevitably lead to higher usage of insecticide and higher operational cost. This will surely not augur well in terms of judicious use of insecticide with regards to integrated pest management as well as the sustainability of the environment and business. Furthermore, prolonged time taken to control the pest will also result in greater degree of pest damage on the palms, which will bring about more negative impact on the crop and the eventual revenue. Hence, it is important to use the optimum rate of the insecticide to achieve fast and complete control of the pest, thus ensuring cost-effectiveness of the pest control operation.

CONCLUSION

Trunk injection is an effective method to judiciously use systemic insecticides for controlling leaf-eating pests on mature oil palm. Based on this study, since monocrotophos and methamidophos insecticides are not available in Indonesia, the use of acephate insecticide is an alternative option available for controlling bagworm outbreaks in Indonesia. This study has clearly proven that acephate 75 per cent

soluble powder mixed with water at 1:1 ratio to obtain a colloidal solution and administered *via* trunk injection, at the rate of 9.4 g a.i. per palm (12.5 g product/palm), can effectively control the larger species of bagworms such as *Dapula (Clania) tertia* infesting oil palm. Hence, there is no problem with using soluble acephate powder in the form of colloidal solution for trunk injection of mature oil palm. The acephate 40 per cent liquid formulation administered neat *via* trunk injection at the rate of 8 g a.i. per palm (20 ml product/palm) was equal in efficacy to the aforementioned. Both soluble powder and liquid formulations of acephate were also found to be better than the dimehypo for trunk injection of oil palm. However, to attain complete control of the leaf-eating pests, the effective rate of the acephate insecticide and the appropriate timing of application, i.e. administered during the voracious feeding of the early larval instar stage, is equally important.

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