

Field Evaluation of Hexaflumuron Bait for Colony Elimination of the Subterranean Termite *Coptotermes curvignathus* Holmgren in Oil Palm Plantation in West Kalimantan Indonesia

by

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Abstract

The number and size of oil palm plantations in Indonesia continues to grow. In West Kalimantan, most oil palm plantations are located in an area dominated by peat soils. This condition makes oil palm trees vulnerable to subterranean termite attack. *Coptotermes curvignathus* Holmgren has been identified as a major pest of oil palm. These termites attack the oil palm trunk, crown, fronds and fruit. Termite control in oil palm involves surface-spraying chemical pesticides, but this type of treatment proves uneconomical and hostile to the environment. In addition, surface sprays are not effective because the termite nest is below ground and the pesticide does not affect the termites inside the nest. Therefore, a new method such as baiting is needed to control termites in the plantation setting. The objective of this study was to evaluate the effectiveness of bait containing the active ingredient hexaflumuron to control *Coptotermes curvignathus* in an oil palm plantation. Three blocks of an oil palm plantation with heavy termite damage was chosen as the test site. Each block consisted of four oil palm trees and bait was placed on one tree within each block. Bait consumption and colony elimination was evaluated every seven days over four consecutive weeks. After colony elimination was determined, the site was evaluated every two weeks for an additional six months to evaluate re-attack of termites. Results showed that seven days after installation, the bait was consumed by termites and consumption remained high (average consumption of hexaflumuron bait from the third block of the test was 95.08%) from week one until week three. Consumption activity began to decline at the end of the fourth week. The decline in termite attack in the oil palm plantations was first observed at the third week where a high soldier to worker ratio was observed; termite population declined to less than 50 and termites shelter tubes were drying. Termites were not observed inside the oil palm fronds by the fourth week. After six months, there was no re-infestation from termites on the baited oil palm tree or the surrounding sample trees. It is concluded that Copton 0.5RB with 0.5% hexaflumuron is effective for colony suppression and elimination of *Coptotermes curvignathus* in oil palm plantations.

Key words: baiting system, *Coptotermes curvignathus*, hexaflumuron, oil palm plantation, termites control

Introduction

Subterranean termites are social insects that work together to sustain large populations. There are three castes in subterranean termites, i.e. worker, soldier and reproductive castes with the workers comprising the majority of a colony tasked with looking for food, sharing food with the colony, maintaining the nest, and taking care of the brood (Nandika et al 2015). Soldiers function to protect the colony and the castes responsible for reproduction. Subterranean termites are generally found in the soil and function as decomposers of organic matter in addition to increasing soil water infiltration and soil nutrients (Robert et al 2007).

Subterranean termites are one of the most economically important pests in buildings, plantations and forests. Lim and Silek (2001) stated that subterranean termites account for huge economic losses in oil palm plantations in Malaysia, especially those on peat soils. Diba (2015) found six species of termites which attack oil palm plantations in West Kalimantan, i.e. *Coptotermes curvignathus*, *Schedorhinotermes javanicus*, *Macrotermes gilvus*, *Odontotermes sp*, *Microtermes sp*, and *Nasutitermes sp*. On average, 75% of all

infestations were caused by the termites *Coptotermes curvignathus*. Nandika (2014) reported *Coptotermes curvignathus* attacks oil palm plantations in Riau Province and caused an average economic loss of Rp 520.000/hectare. The cost for termite control is a big expense as shown by the annual cost of termite control in the United States \approx \$1.5 billion (Su 1991).

Traditional termite control in oil palm plantations consist of spraying termiticide on oil palm trees as a remedial approach. This method is very effective in controlling termites that contact the termiticide but much less effective to termites inside the trunk and below ground. Termites in the trunks of palm oil trees as well as the underground nest may attack other trees in the oil palm plantation. Termite baits are a new control technology utilizing chitin synthesis inhibitor (CSIs) active ingredients. These CSIs display a different mode of action providing an effective and environmentally friendly alternative. One of the active ingredients used in termite baits is hexaflumuron. Hexaflumuron was the first active ingredient registered with the US EPA as a reduced-risk pesticide and has been reported to successfully eliminate the Formosan and eastern subterranean termites in laboratory tests and field trials (Scheffrahn and Su 1991, Su and Scheffrahn 1993, Su 1994). Sajap et al (2000) reported hexaflumuron is effective against *Coptotermes curvignathus* in Malaysia. The objective of this research is to evaluate hexaflumuron in a baiting system for effectiveness against *Coptotermes curvignathus* in an oil palm plantation.

Materials and methods

Experimental site

The oil palm plantation was located in Purun District, Mempawah Regency, and West Kalimantan Province, Indonesia. The location was approximately 120 Km West of Pontianak City, Indonesia. The oil palm plantation was on peat soil with a total area of 2800 hectares. The peat ranged in depth from 0.75 m to 1.5 m with an average daily temperature of 26.5°C and 85% relative humidity. The research site was located in blocks with very high termite attack (termites attacked more than 20 oil palm trees in one block). The blocks consisted of Block H 40, H 41 and H 42. Four oil palm trees were used in each block.

Termite Baiting System

Termite baits used in this study were Copton 0.5 RB termite bait with 0.5% hexaflumuron obtained from Dow AgroSciences, LLC. One 30 g Copton 0.5 RB hexaflumuron bait was placed inside an oil palm frond infested with termites and left for one month (Figure 1).



Figure 1. Installation of Copton 0.5 RB termite bait with 0.5% hexaflumuron bait inside the oil palm frond

Evaluations of bait consumption and termite elimination were conducted every seven days. At one month the bait was removed from the tree, cleaned, measured, and weighed. Termite baits were weighed to determine the percentage of weight loss based on the formula of Sornnuwat et al (1996):

$$\text{Bait weight loss (\%)} = \frac{(W_1 - W_2)}{W_1} \times 100\%$$

W1 = initial weight of bait
 W2 = weight of bait after one month installation

Termite colony vigour was analyzed according to Garcia et al (2007). The total number of termites, including the ratio of workers to soldiers, was recorded. Termites were classified as abundant, moderately abundant, few, and none (Table 1), at each monitoring interval.

Table 1. Classification of *Coptotermes curvignathus* Holmgren numbers in baits

Population	Classification
0	None
1 to 20	Few
21 to 50	Moderately abundant
Over 50	Abundant

Source: Garcia et al 2007

After bait removal, we monitored oil palm trees for re-infestation by termites. Rubber wood (2 cm x 2 cm x 30 cm) monitoring devices were installed around oil palm trees and evaluated for termite attack for six months (Figure 2). The top of the wood was colored with red paint to aid monitor locating.

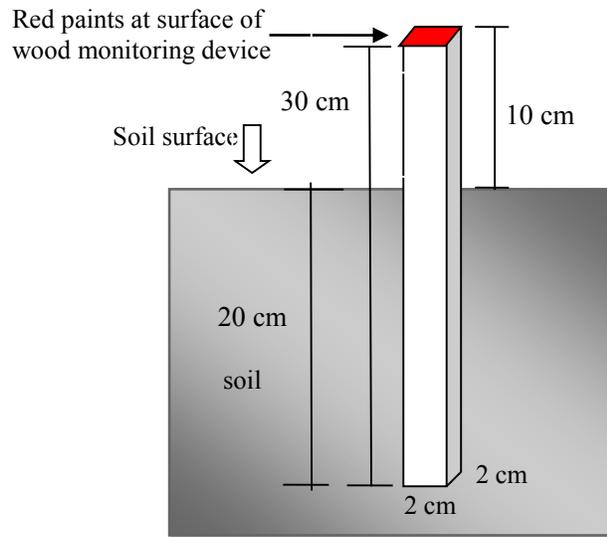


Figure 2. Installation of Wood Monitoring Device

Wood monitor stakes were installed vertically into the ground with 2/3 buried (20 cm). Each oil palm tree had four monitoring wood stakes; three within a 1.5 meters radius and one placed on the oil palm tree (Figure 3). Observations were made every two weeks for six months.

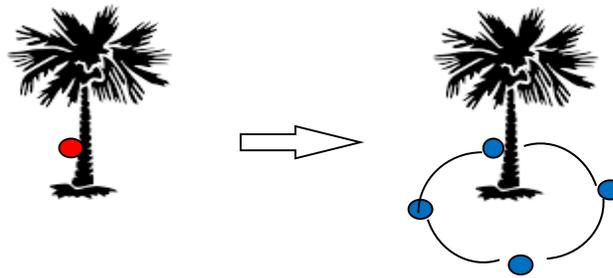
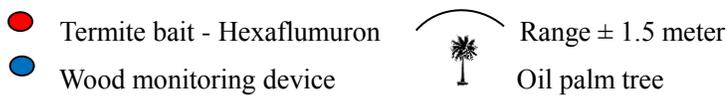


Figure 3. Schematic of monitoring device placement.



Coptotermes curvignathus Holmgren infestation was observed on the trunk, part of the fronds, the apical growth, and the fruit bunches of the palm trees. Hermawan et al (2014) states oil palm has high cellulose, with average holocellulose content of 82.534% ~ 88.328%, alpha cellulose content of 11.243% ~ 68.761%, and lignin content of 6.213% ~ 33.702%. The intensity of termite *C. curvignathus* attack on oil palm was categorized as heavy and very heavy. Heavy attack consisted of termite galleries on the trunk up to the apical growth but with green leaves and fronds. The category Very Heavy consisted of termite galleries on the trunk up to the apical growth with dry leaves and fronds. Cheng et al (2008) and Kirton et al (1999) reported that *C. curvignathus* is a pest of oil palm plantations in peat soil in Malaysia and Forest Plantation Area of *Acacia mangium* Willd.

The percentage of hexaflumuron baits infested with termites at the first observation (7 days after installation) was 83% (N=10) and 100% by the second observation (14 days after the installation). A large number of termite workers (greater than 50) were found in each bait. These observations indicate that Copton 0.5 RB termite bait with 0.5% hexaflumuron is not repellent to termites and acceptance rate was very fast. Diba (1999) revealed that hexaflumuron bait started to be consumed by termites 2 days after installation, and by the second week the entire bait was fully covered by soil and with greater than seventy percent consumed. The condition of hexaflumuron bait is presented in Figure 4.



Figure 4. Condition of Copton 0.5 RB termite bait with 0.5% hexaflumuron bait at 7 days after installation (a), 14 days after installation (b) and 21 days after installation (c)

One month after installation, average weight loss of Copton 0.5 RB termite bait with 0.5% hexaflumuron was 96.25% in Block H 40, 96.50% in Block H 41 and 92.50% in Block H 42. Average consumption across the three blocks was 95.08%. These results demonstrate that Copton 0.5 RB termite bait was readily accepted by termites. Hexaflumuron has a slow mode of action allowing termites to feed on the bait and spread the active ingredient throughout the colony before symptomology begins (Su et al 1995, Pawson and Gold 1996). These results are in agreement with Castillo et al (2013) who reported that termites choose the most appropriate type of cellulose containing food. Average consumption of Copton 0.5 RB bait by *C. curvignathus* for each block is presented in Figure 5.

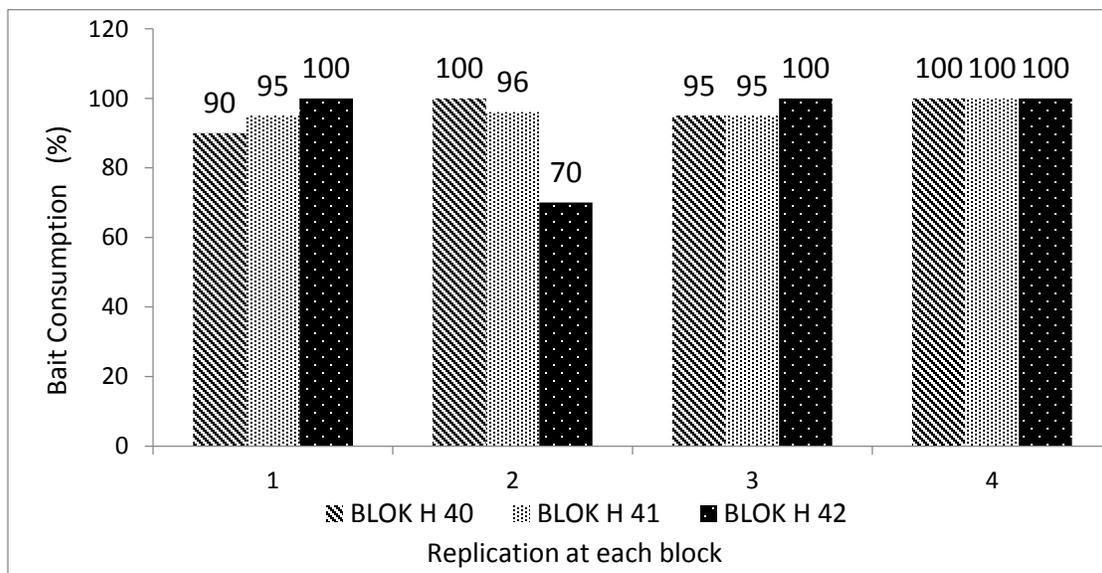


Figure 5. Copton 0.5 RB bait consumption by *Coptotermes curvignathus* in Oil Palm in West Kalimantan Province

The impact on termite colonies that consumed the bait increased from week one to week three as indicated by the higher soldier to worker (S/W) ratios. When greater than 50 termites were found in monitoring baits the population consisted mostly of workers. Populations found in baits of less than 50 had a higher proportion of soldiers. Consumption of bait began to decline by the end of the fourth week. It is suspected that by the end of the fourth week the hexaflumuron suppressed the termite colonies, as indicated by a reduced termite population, and a decline in termite attack on the oil palm trees. Evidence of dry soil mud tubes, and no termites found inside the oil palm fronds provided visual confirmation of reduced termite attack. The high soldiers to worker ratio are reported in Table 2.

Table 2. Estimation of termite population (P) and ratio of soldiers to workers (S/W) found at each oil palm tree during monitoring period

Oil Palm sample	Inspection period (days)									
	7		14		21		28		40 - 180	
	P	S/W	P	S/W	P	S/W	P	S/W	P	S/W
1	>50	S < W	>50	S < W	<50	S > W	-	-	-	-
2	>50	S < W	<50	S > W	-	-	-	-	-	-
3	>50	S < W	<50	S > W	-	-	-	-	-	-
4	>50	S < W	>50	S < W	>50	S < W	<50	S > W	-	-
5	>50	S < W	>50	S < W	>50	S < W	<50	S > W	-	-
6	>50	S < W	>50	S < W	<50	S > W	-	-	-	-
7	>50	S < W	>50	S < W	<50	S > W	<50	S > W	-	-
8	>50	S < W	>50	S < W	>50	S < W	<50	S > W	-	-
9	>50	S < W	>50	S < W	<50	S > W	-	-	-	-
10	>50	S < W	>50	S < W	>50	S < W	<50	S > W	-	-
11	>50	S < W	>50	S < W	<50	S > W	-	-	-	-
12	>50	S < W	>50	S < W	>50	S < W	<50	S > W	-	-

Colony eliminations were noted four weeks after installation of Copton 0.5 RB termite bait and all activity was successfully eliminated at 40 days (Fig. 6). No oil palm tree re-infestation was observed at 180 days.

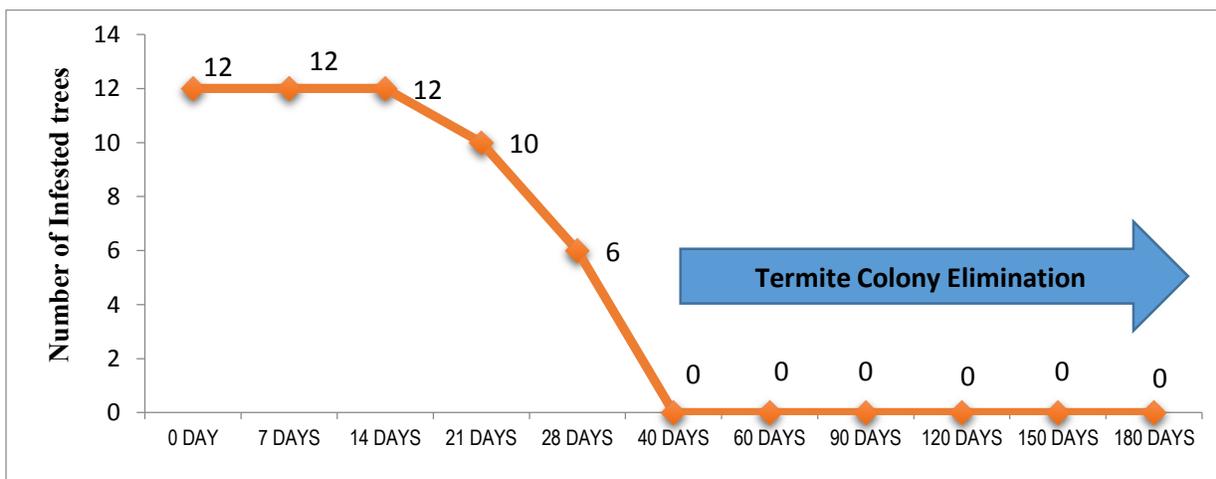


Figure 6. Colony suppression and elimination of *Coptotermes curvignathus* after consumption of Copton 0.5 RB termite bait in Oil Palm Plantation in West Kalimantan Province.

Termite re-infestation of oil palm trees was 0%, as shown by the absence of termite attack on the wood monitoring devices for six months. These results are in agreement with Sajap et al (2009) where a Preferred Textured Cellulose (PTC) matrix with 0.5% hexaflumuron was reported to eliminate *Coptotermes gestroi* and *Schedorhinotermes* sp colonies in oil palm plantations in Malaysia. Colony elimination occurred 42-77 days after bait installation with bait consumption between 22.93 to 167 grams. Nandika (2014) stated that the absence of re-infestation of oil palm trees by termites indicated that termites were eliminated.

C. curvignathus have been identified as the major pest in oil palm plantations. Immature oil palm trees are the most vulnerable to termite attack (Woei Kon et al 2012). Khoo et al. (1991) reported *C. curvignathus* also attack *Acacia mangium* and *Hevea brasiliensis* plantations. Current control methods for *C. curvignathus* in oil palm utilize liquid pesticide applications. Liquid pesticide application requires spraying and drenching the trunk, fronds, and leaves of oil palm. Treatment of the soil around infested trees is another control option to prevent termite attack. These treatments have proven to be non-economical because the termite nest is not directly treated leading to infestation of other oil palm trees. Therefore, new control strategies for termite control in plantations are needed. Termite baiting is an environmentally friendly method with reduced risk against non-target organisms. Copton 0.5 RB termite bait with hexaflumuron eliminated termite colonies in oil palm plantations as demonstrated by this research. Copton 0.5 RB utilizes the feeding behavior of termites to spread the active ingredient hexaflumuron throughout an entire colony. The natural behavior of food sharing, or trophalaxis, involves a relatively small number of termites in a colony feeding on a bait, and subsequent transfer of that toxic material to nest mates. Copton 0.5 RB termite bait has proven to eliminate *C. curvignathus* colonies in oil palm plantations.

Conclusions

The use of Copton 0.5 RB hexaflumuron termite bait is an effective and economical method to control *Coptotermes curvignathus* Holmgren in oil palm plantations. Copton 0.5 RB bait was tested and showed a high level of preference by *C. curvignathus*. Average bait consumption was 95.08% by one week and after three weeks we recorded high soldier to worker ratios. Termite activity was greatly reduced by four weeks indicating quick suppression of termite colonies. Copton 0.5 RB termite bait eliminated colonies of *Coptotermes curvignathus* Holmgren in oil palm plantations within 40 days.

Acknowledgment

The authors sincerely thank to PT Peniti Sungai Purun and staff for help during the research activities, to PT. DOW Agro Sciences Indonesia and special thanks to Dr. Neil Spomer and Dr. Joe De Mark (Dow AgroScience LLC Indianapolis, IN) for support funding, technical review and final approve for external release from information release request # 20160716.

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