The Planter, Kuala Lumpur, ***97*** *(1140): 163-171 (2021)*

Application Methods of Coumatetralyl Baits to Control *Rattus rattus diardii* in High Infestation Areas

BALASUBRAMANIAM, R

BPP Agraria Sdn Bhd, No. 3, Jalan 5/19, Section 5, 46000 Petaling Jaya, Selangor Darul Ehsan, Malaysia.

The most widely practiced method of rat control in oil palm plantations is by baiting with anticoagulant rat poisons. Two experiments were conducted to study the efficacy and susceptibility of first-generation anticoagulant rat bait, coumatetralyl (0.375%) to control Rattus rattus diardii.

In the first experiment, a laboratory trial was conducted to test two commercial coumatetralyl 0.375 per cent rat baits (5 g and 6 g) and one brodifacoum bait (5 g) in comparison with an untreated control. All the three baits provided excellent kill of Rattus rattus diardii. *The results indicated that,* Rattus rattus diardii *from the locality of Sampit in Central Kalimantan was susceptible to first-generation anticoagulant of coumatetralyl and coumatetralyl baits were highly palatable. The laboratory findings prompted to evaluate the efficacy of first-generation bait in the field.*

The second experiment was conducted in an 18-year-old mature oil palm field to evaluate coumatetralyl rat bait in three baiting treatments to control high rat infestation with high fresh damage (*18%; 12%; 15%; 17%*) *of* Rattus rattus diardii. *The coumatetralyl wax bait was evaluated with one bait per palm (replacement at 4 days interval), three baits per palm (replacement at 7 days interval) and five baits per palm (replacement at 7 days interval); and an untreated control treatment was included. All the three baiting treatments provided successful control of rats and reduced the rat population to a negligible level. The standard baiting treatment required nine baiting rounds. The three baits per palm and five baits per palm treatments needed eight and five baiting rounds respectively. The fresh damage on fresh fruit bunches (FFB) in all the three treatments were observed to have reduced from high level to 0 per cent. The first-generation coumatetralyl anticoagulant bait was effective for the control of* Rattus rattus diardii.

Hence, it is good approach to use the first-generation baits (for example coumatetralyl bait) in susceptible rat population areas until such time the change to second generation rodenticide bait is required. Placements of more baits required fewer baiting rounds but may result in over application of baits which lead to high cost. Therefore, multiple bait application is not recommended for routine baiting campaigns. It is relatively an interim measure for quick reduction of rat populations especially in high infestation areas.

Keywords*: Oil palm, high rat population, baiting, first-generation anticoagulant, coumatetralyl,* Rattus rattus diardii.

Indonesia is currently leading the world in palm oil production after rapid growth in several parts of Indonesia. This plantation crop has been cultivated over large areas in the province of Central Kalimantan. There are several pests affecting and causing heavy damage to oil palm. However, rats are considered the major key pests amongst the many pests affecting oil palm plantations. Rats can cause substantial damage resulting in significant economic losses

email:bala@bpp.ag

to young and mature oil palm. The effect of rat damage during immature phase causes subsequent adverse effect on the early yield of oil palm. Heavy damage of lower fronds caused by rat chewing the frond bases has resulted in yield loss of 24 per cent in the first-year of harvesting compared with undamaged palms (Chung *et al*., 1999). Rat damage is usually most apparent and serious in mature plantings. In mature palms, the main attribute of rats is their feeding on ripe and unripe fruits including detached loose fruits on the ground. Very severe damage and crop losses may occur when the rat population increases significantly. Uncontrolled rat damage can result in 7-10 per cent loss of oil production (Liau, 1990). However, in very high rat infestation situations, the losses can be much higher, because male and female inflorescences and developing bunches would also be seriously damaged. Balasubramaniam and Chung (2018) calculated that, at high rat population (718 rats/ha) the potential oil loss is 1300 kg per hectare per year.

There are several species of rats reported as pests of oil palm. These include *Rattus tiomanicus*, *Rattus argentiventer*, *Rattus rattus diardii*, *Rattus tanezumi*, *Rattus exulans* and *Rattus muelleri* (Kalshoven, 1981; Lubis, 1992; Adidharma, 2002; Sumantri & Wood, 2012; Andru *et al*., 2013; Chung, 2015). In the early days of oil palm cultivation, *Rattus tiomanicus* was the only rat species regularly found in Peninsular Malaysia (Wood, 1968). However, from the mid-eighties onwards, changes in rat species occurred. *Rattus rattus diardii* appeared to be the main species to replace *Rattus tiomanicus* in several locations in Malaysia (Mohd Mat Min, 1985). Wood *et al*. (1988) estimated that, the population of *Rattus rattus diardii* was between 154 - 260 rats per hectare when no control measures was carried out. Liau *et al*. (1993) found that, *Rattus rattus diardii* was the dominant species detected in certain oil palm areas in Malaysia. Coumatetralyl resistance was reported on *Rattus tanezumi* infesting oil palm plantations in Indonesia (Bangka) by Andru *et al*. (2013). Recently, *Rattus rattus diardii* has been found to be the sole rat species and well adapted in mature oil palm areas near Sampit in Central Kalimantan, Indonesia (Balasubramaniam & Chung, 2018).

Effective rat control to prevent crop losses in oil palm estates is best achieved through maintaining low pest population. Conventionally and more frequently rats are controlled by using anticoagulant wax-bound baits to reduce their populations and to minimise damage (Wood *et al*., 1990). Anticoagulant rodenticides are formulated into various forms of wax bound baits in commercial products for rat control. The rodenticides are grouped into first and second generations anticoagulants. The commonly used first-generation rodenticides in oil palm estates are warfarin, chlorophacinone and coumatetralyl. In some plantations, the second-generation anticoagulant such as bromadiolone and brodifacoum were introduced in areas where rats have developed resistance to the first-generation anticoagulant baits. In Indonesia and Malaysia, the first generation of rat baits are being used in many and newly developed plantations (Chung, 2012).

The application of first-generation rat bait with one bait per palm and replacement at 4-day intervals until the acceptance level is decreased to 20 per cent provided effective control of rats (Wood & Nicol, 1973; Wood & Liau, 1984). Generally, good rat control is achieved through regular baiting campaigns at 6-monthly, since the rat populations once reduced will start to increase at about that time. The advantage of baiting at 6-monthly

campaign is to maintain the rat damage and the population at low level.

A laboratory and field trials were carried out to study the efficacy of first-generation rat bait and several baiting treatments were evaluated for rapid control of *Rattus rattus diardii* in high infestation areas with fresh damage ranging from 12 - 18 per cent.

METHODS AND MATERIALS

No choice feeding test

A laboratory no choice feeding was undertaken to evaluate the effectiveness of two commercial wax block baits containing 0.375 per cent coumatetralyl (5 g and 6 g) and compared with brodifacoum 0.05 per cent (5 g) bait. Rats (*Rattus rattus diardii*) were collected by live trapping from an oil palm estate in Sampit, Central Kalimantan. The rats were acclimatised to laboratory conditions and kept in wire-mesh cages each measuring 28.5 cm x 13 cm x 10 cm (1 rat per cage) for 2 weeks prior to experimentation. During the acclimatisation period the rats were fed with a laboratory diet (oil palm fruits, papaya, banana and bread with milk solution) as often as necessary and water was available at all times. The animals were sexed and weighed before subjecting to laboratory feeding test. Each treatment was tested by no choice feeding to five male and five female rats. Each rat was offered one bait at every 4-day interval until they died (*Figure 1*). Fresh food was given according to the standard laboratory diet (as mentioned earlier), when rats were not subjected to poison treatments, while water was available *ad libitium*. For comparison the standard laboratory food and water was given *ad libitium* in the control treatment. Rats were observed daily for 30 days and days of death recorded for each rat.

Baiting experiment

A field experiment was implemented in an 18-year-old oil palm field near Sampit, Central Kalimantan. The trial site was flat and gently undulating. The field was plagued with high populations of *Rattus rattus diardii* at the time the trial was initiated (*Figures 2* and *3* illustrate the damage caused due to high rat populations). Barn owls had been reasonably established in this estate and rat baiting had been stopped for a few years. However, the barn owls were unable to provide effective control. Approximately, the ratio of barn owl boxes was

Figure 1 Rats kept in individual cages fed poison bait

Figure 2 Fresh rat damage on fruit bunch

Figure 3 Old damage on fruit bunch

1:30 and the average of occupancy was about 65 per cent.

The baiting trial evaluating 6 g coumatetralyl (0.0375%) block wax baits were applied at three baiting treatments as follows:

a) Applying one bait per palm at every palm (100% density) and replaced at 4 days interval when bait was taken away,
b) Applying three baits per palm at every palm (100% density) and replaced at 7 days interval when all baits were taken away,
c) Applying five baits per palm at every palm (100% density) and replaced at 7 days interval when all baits were taken away, and
d) Untreated control; no baiting carried out.

Each treatment was applied in single large

plots approximately 9 to 10 hectares in a contiguous field which was infested with high rat populations. The baits were placed in the weeded circles at a predetermined spot, in order to ease checking. Rat baiting was stopped when the acceptance level reached 20 per cent or below.

The rat trapping plot comprising of 5 x 10 palms was set up in the middle of each plot. Live trapping of rats was carried out in each plot for four consecutive nights using catch, marked and release (CMR) method (Wood & Nicol, 1973; Wood & Liau, 1984; Balasubramaniam & Chung, 2018) before and immediately after complete baiting. The rat population estimates were calculated by using Lincoln Index (Bailey corrected) method (Wood, 1984; Liau, 1990; Wood *et al.*, 1990). Fresh damage assessment on fresh fruit bunches (FFB) was recorded in 100 palms plot (surrounding the trapping plot) before and end of baiting. Similarly, the number of dead rat carcasses was recorded in the 100-palm plot at every baiting round.

RESULTS AND DISCUSSION

No choice feeding test

Results (*Table 1*) of this laboratory study indicated that, both coumatetralyl baits (6 g and 5 g) and brodifacoum baits (5 g) were well accepted and highly effective against *Rattus rattus diardii*. No marked difference was recorded between coumatetralyl 5 g bait and brodifacoum 5 g bait in terms of number of baits required to kill. Both coumatetralyl 5 g and brodifacoum 5 g baits required an average of 3 and 3.3 baits respectively to attain very good mortality. However, coumatetralyl bait at 6 g recorded an average of 3.9 baits to achieve 100 per cent mortality. Similarly, coumatetralyl 5 g bait was as effective as brodifacoum 5 g bait in terms of number of days to kill. These treatments obtained approximately 11 - 12 days to mortality as compared to coumatetralyl, 6 g bait which achieved by about 14 days. This laboratory study confirmed that, *Rattus rattus diardii* from Sampit areas is highly susceptible to the first-generation bait containing coumatetralyl.

Field trial

The data on fresh damage, rat population (before and after baiting), dead rat count and baiting rounds are tabulated in *Table 2*. After completing the baiting rounds in all the three treatments, the fresh damage on FFB were successfully reduced from the range of 12 - 18 per cent to 0 per cent level except in control treatment which recorded 12 per cent fresh damage. The baiting treatments with high rat populations initially, were very much to negligible level after complete baiting. In the three baiting treatments, (1 bait/palm, 3 baits/palm and 5 baits/palm) the estimated populations before baiting were 890, 590 and 612 rats per hectare, respectively. The successful baiting in the three treatments clearly showed marked decline in rat population to six, five and nine rats per hectare. However, there was some decline in population in the non-baited plot from 718 rats per hectare to 418 rats per hectare. This could be due to the migration of rats from non-baited area to the baited or other areas because rats are highly mobile and move rapidly into areas with low populations.

The dead rat count for all the baiting treatments were 18, 24 and 21 respectively indicating the baits were well accepted and effective in the field. The standard treatment with one bait per palm required nine rounds of application to achieve good control. Treatments with three baits per palm and five baits per palm needed eight rounds and five

TABLE 1
THE EFFECT OF COUMATETRALYL AND BRODIFACOUM RAT BAITS ON THE MORTALITY OF *RATTUS RATTUS DIARDII* (SAMPIT AREAS) IN LABORTAORY NO CHOICE FEEDING TEST

*Treatment**	*Bait size*	*Total rats*	*Mean weight (g)*			*Mean no. of baits given*			*Mean days to death*			*No. of rats killed*		*Total kill*	*% Mortality*
			M	*F*	*Ave.*	*M*	*F*	*Ave.*	*M*	*F*	*Ave*	*M*	*F*		
Coumatetralyl 0.375%	6 g	10	125.2	159.6	142.4	3.8	4.0	3.9	13.2	15.0	14.1	5	5	10	100
Coumatetralyl 0.375%	5 g	10	122.0	158.4	140.2	3.2	2.8	3.0	11.2	13.0	12.1	5	5	10	100
Brodifacoum 0.05%	5 g	10	123.0	163.8	143.4	3.4	3.2	3.3	11.4	10.8	11.1	5	5	10	100
Untreated control	-	10	124.4	160	144.2	0	0	0	0	0	0	0	0	0	0

*1 bait given at 4-day interval

TABLE 2
THE EFFECT OF THREE COUMATETRALYL BAITING TREATMENTS ON THE CONTROL OF *RATTUS RATTUS DIARDII* (SAMPIT AREAS) IN 18-YEAR-OLD OIL PALM

Treatment / a.i. conc.	*Bait size*	*Baits/ palm*	*App. freq. (days)*	*Plot size*	*Pre-baiting*		*Dead rat count*	*Baiting rounds*	*Post baiting*		*Total baits*	*Bait/ ha*
					% FD	*Est. popl*			*% FD*	*Est.popl.*		
Coumatetralyl 0.375%	6 g	1	4	10.17	18	816	18	9	0	6	8474	831
Coumatetralyl 0.375%	6 g	3	7	9.23	12	590	24	8	0	5	19957	2162
Coumatetralyl 0.375%	6 g	5	7	9.21	15	612	21	5	0	9	19811	2151
Untreated control	-	-	-	9.54	17	718	0	-	12	418	-	-

Note: a.i.-active ingredient; App. freq.- application frequency; FD- fresh damage; Est.pop.- estimated population

rounds respectively. Single bait application required more labour input compared with the other baiting treatments. However, there is only a little difference between one bait per palm and three baits per palm in terms of baiting rounds. Lowest baits required in the standard baiting treatment with 831 baits used per hectare (100%). Significantly more baits were used in three baits per palm and five baits per palm treatments which recorded 2 162 baits per hectare (260%) and 2 151 baits per hectare (259%) respectively.

The results of the laboratory test indicated that, *Rattus rattus diardii* in Sampit areas did not develop resistant to first-generation bait. The field trial demonstrated effective control of the high population of *Rattus rattus diardii*. Chung (2012) suggested that it is better to start with the first-generation baits as long as the rats are susceptible.

It is important to monitor regularly the damage level on FFB. There seemed to be some correlation between the rat population and percentage of palms with fresh damage occurrence on FFB (Balasubramaniam & Chung, 2018). The level of fresh rat damage on FFB would give some indication of rat infestation in any area. Mohd Mat Min (1985) suggested that control measures should be initiated when the damage level exceeded 5 per cent. However, Liau (1990) pointed that for older palms control measure is required when the fresh damage is approximately 1-2 per cent instead of baiting at 5-10 per cent fresh damage. This is because damage scores with corresponding rat populations are lower as the palms get older and taller due to the difficulty in visually detecting the fresh damage. Good control can be achieved as long as the baits are accepted by the rats (Chung, 2014). After baiting, the dead rat count, zero fresh damage level and low number of rats indicated the baits were well accepted and susceptible to the coumatetralyl anticoagulant. Longer duration of 7 days interval is required for all baits to be completely taken when more baits were applied.

Rat populations do not increase indefinitely. They fluctuate slowly over a period of time and then the population rapidly builds-up. In the absence of control, it is always large enough to cause economic losses. Biological control by barn owl only provides a certain degree of control when the rat infestations is very high. Rat control by predator alone may not be the best option in oil palm plantations (Chua *et al*., 2007). Although the barn owl has been established widely in many plantations, it cannot be considered an effective rat control measure (Chung, 2014). Therefore, effective rat control would be an integrated approach in both biological and chemical baiting. Hence, a standard systematic rat baiting campaign at 6-monthly intervals can effectively keep the rat population at low level (Wood & Nicol, 1973; Wood & Liau, 1984).

The number of baiting rounds depends on the current in-situ rat population. In high rat population areas, the number of baiting rounds varies from 10-15 rounds (Chung, 2012). With the current labour constrains, it is becoming more difficult to conduct rat baiting up to ten or more rounds in areas with high rat populations. Based on experience, the application of more baits can reduce the number of baiting rounds. However, in terms of usage of baits per hectare, the application of more baits is very much higher compared to one bait per palm. Although, the cost comparison inputs are not mentioned in this paper, the material cost for more bait treatments, is certainly higher than the single bait application. Chung and Balasubramaniam (2000) reported that the application of second-

generation rat baits with five baits per palm and ten baits per palm gave effective control of rats but not cost-effective compared with the standard baiting technique with one bait per palm. Hence, due to high material inputs, placement of more baits is not advocated for normal baiting campaigns. More baits application is relatively a good strategy for quick reduction of rat populations especially in high infestation areas with fewer baiting rounds.

CONCLUSION

The laboratory and field trial findings indicated no incidence of resistance to first-generation anticoagulant, coumatetralyl. Coumatetralyl rat baits gave effective control of *Rattus rattus diardii* in both laboratory testing and field trial in 18-year-old oil palm. Hence, it is a good approach to use the first-generation baits in susceptible rat population areas until such time when the change to second generation rodenticide bait is required. It may not be suitable to control *Rattus tanezumi* infesting oil palm plantations in Indonesia which has been reported to be resistant to coumatetralyl in certain locations.

Efficient rat control with rodenticides remains the most widely used technique in oil palm estates. Hence, the standard baiting with one bait per palm at 4 days interval of 6-monthly baiting campaigns can keep the rat population at low level and prevent the increase of infestations. However, in the case of acute infestation of high rat populations, more baiting rounds are required which will incur high labour inputs. Placements of more baits required fewer baiting rounds but may result in over application of baits which lead to high cost. Therefore, multiple baits application is not recommended for routine baiting campaigns. However, it is relatively an interim measure for quick reduction of rat populations especially in high infestation areas.

ACKNOWLEDGEMENT

The author would like to thank Mr Chung Gait Fee for his comments and useful suggestions on the manuscript and to Mr Prathapan Pillai, the Executive Chairman of BPP Agraria Sdn Bhd, for his support and encouragement.

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