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# The Bioefficacy of the Aggregation Pheromone in Mass Trapping of Rhinoceros Beetles (*Oryctes rhinoceros* L.) in Malaysia*

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*This paper reports a series of experiments and commercial evaluation from 1994 to 1996 evaluating the bioefficacy of the aggregation pheromone (ethyl 4 - methyloctanoate) of* Oryctes rhinoceros. *The aggregation pheromone has been found to be highly effective for mass trapping of rhinoceros beetles, at the optimum density of one trap per 2 hectares. Mass trapping was effective in the reduction of damage at low pest population. It is 31 per cent cheaper in cost and 86 per cent less in labour requirement (comparing to conventional control by carbofuran application). It was effective in trapping large number of beetles in high pest population but palms were still damaged. It can also be used effectively in IPM packages for removal of beetles, monitoring of beetle population and biological control.*

***Keywords**: Rhinoceros beetles,* Oryctes rhinoceros, *aggregation pheromone, mass trapping, oil palm.*

Pheromones are chemicals used for communication between two or more animals of a single species. The most conspicuous use of pheromone by insects is in causing other members of the same species to aggregate in a particular area. Hallett, Perez, Gries G, Gries R, Pierce, Yue, Oechslager, Gonzalez and Borden (in press) reported that ethyl 4 - methyloctanoate was the aggregation pheromone (AP) of *O. rhinoceros*. Experimental samples in the form of slow release formulation contained in small plastic sachets were sent to Malaysia for bioefficacy evaluation. A series of simple experiments and commercial evaluation were conducted from 1994 onwards to evaluate this AP for its bioefficacy in the mass trapping of *O. rhinoceros* in immature and mature plantings of several oil palm plantations in West Malaysia. This paper reports the findings of these experiments and discusses the potential benefits and possible use of this AP for integrated pest management (IPM) of *O. rhinoceros* in oil palm plantations.

## EVALUATION OF AP

The AP was evaluated in palms of different ages and in different locations. The methods and results of each trial are reported separately.

### *Evaluation of AP in two-year-old planting at Kampung Kuantan*

Three treatments (namely: bucket trap with empty fruit bunches (EFB), bucket trap with wet gunny cloth + AP sachets, and bucket trap with EFB + AP sachets) were

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evaluated in two-year-old planting with severe infestation of *O. rhinoceros* using single bucket trap replicated ten times in a randomised complete block design. Each bucket trap had four entry holes in the upper position of the bucket. One cut frond was placed on each entry hole to facilitate beetle climbing up. The beetles caught were sexed and their number recorded at weekly intervals upto nineteen weeks.

The AP was proven to be effective in the mass trapping of *O. rhinoceros*. More females than males were caught. In the AP + EFB treatment, a total of 213 beetles (186 females and 27 males) were caught in the nineteen weeks trial period. Similarly, AP + wet gunny cloth treatment collected a total of 228 beetles (189 females and 39 males). The sachets were effective for up to thirteen weeks. One or no beetle was caught from fourteen weeks onwards.

*Evaluation of AP in two trap designs in three-year-old planting at Kampung Kuantan*

The bioefficacy of AP in bucket traps and vane traps were evaluated in a three-year-old planting with severe infestation of *O. rhinoceros*. The two types of traps were compared using randomised complete block design and each trap was replicated five times. The bucket traps were placed above ground in between two palms and the vane traps were hung by a wooden support about 3 m above ground. The beetles caught were sexed and their number recorded at weekly intervals for upto twelve weeks.

The vane traps were far superior to the bucket traps when evaluated in pair. Beetles were caught as early as from the second day and the catch continued upto eight weeks. No catch was recorded from the ninth to the twelfth week. A total of 230 beetles were caught in the five vane traps; 168 were females and fifty-two males. The mean total catch per vane trap was forty-six. The mean total catch per bucket trap was only 1.2.

*Evaluation of AP using vane traps*

The bioefficacy of AP in vane traps hung by wooden support at about 3 m above ground at a density of one trap per 2 hectares was evaluated in a number of areas. The beetles caught were sexed and their number recorded at weekly intervals. The AP sachets were replaced when beetle catch decreased to zero or very low number.

*Evaluation of AP in three-year-old planting at Kuala Selangor.* A total of twelve traps were placed uniformly over a 24 hectare plot. Non-painted vanes and black coloured vanes (6 of each type) were evaluated in pairs.

The black coloured vane was superior and caught 1.5 times more beetles than the non-painted vane (*i.e.* 715 *vs* 460). The mean per trap per week ranged from 0-6.3 beetles and 0-12.5 beetles for non-painted vane and black coloured vane respectively. The AP sachets were effective for eight to ten weeks.

*Evaluation of AP in two-year-old planting at Teluk Intan.* The evaluation was on a two-year-old planting with serious infestation of *O. rhinoceros*. A total of sixteen traps placed uniformly were used.

The AP sachets were effective for seven to nine weeks. A total of 7 159 beetles were collected in the fifty-four weeks duration. More females (4 694) than males (2 465) were caught at the ratio 1.9: 1. The highest catch occurred at thirty-seven weeks with a total catch of 710 beetles. The mean beetle catch was 8.29 per trap per week.

*Evaluation of AP in two-year-old planting at Kapar.* The bioefficacy of AP was evaluated in a two-year-old planting with serious infestation of *O. rhinoceros*. A total of fourteen traps were uniformly placed over a plot of 28 hectares.

The AP sachets were effective for six to nine weeks. The total number of beetles caught were 2 241 (1 648 females and 593 males) in twenty-eight weeks of trapping *i.e.* more females than males were caught (in the ratio of 2.78: 1). The mean beetle catch was 5.72 per trap per week.

*Commercial evaluation of AP in three-year-old planting in Batang Berjuntai.* The bioefficacy of AP in vane traps hung by wooden support was evaluated over a commercial planting of 117.4 hectares. A total of fifty-seven traps were used.

The AP sachets were effective for seven to eight weeks. The AP sachets were replaced at approximately two months interval. In this planting, slightly more males (4 651) than females (4 117) were collected, from August 95 to May 96 (*i.e.* 40 weeks). Therefore, the mean beetle catch was 3.85 beetles per trap per week.

*Commercial evaluation of AP in one-year-old planting at Paloh.* This evaluation was on a commercial planting of 354 hectares. A total of 177 traps were used.

The total number of beetles caught increased from 2 197 in the first week to the highest catch of 6 600 in the thirteenth week and gave a mean value of 15.3 beetles per trap per week. The proportion of males (21 030) and females (25 074) were about similar. The overall catch was 46 104 beetles over a seventeen weeks period.

*Commercial evaluation of AP in newly planted oil palm at Teluk Intan.* This evaluation involved commercial planting of 98.5 hectares. A total of forty-eight traps were used. The traps were set up immediately after completion of light burning of the old crop residue. The first batch AP sachets in twenty-eight traps were reused from an earlier trial. Their effectiveness lasted for six weeks with a total catch of 400 beetles (282 females and 118 males). The new sachets from the second batch in forty-eight traps were effective for upto eight weeks. A total of 727 beetles (515 female and 212 males) were caught. The mean beetle catch was 1.89 per trap per week. It was obvious that many beetles were flying into the new plantings either searching for food or for oviposition sites.

*Evaluation of AP at four different trap densities in one-year-old planting at Paloh*

The bioefficacy of AP using vane traps was evaluated in four plots with four trap densities in a one-year-old planting with severe infestation of *O. rhinoceros*. The details of these treatments and results are given in *Table 1*.

The total number of beetles caught increased with the increase in trap density, *i.e.* two traps per hectare and five traps per hectare had higher catch. However, the efficacy of trapping declined with increasing trap density and the mean number of beetles caught per trap was lowest for the highest trap density of five traps per hectare. The mean beetle catch at one trap per 2 hectares was fourteen per trap per week.

*Evaluation of AP in five-year-old planting at Jeram*

Mature palms in a five-year-old planting adjacent to a one-year-old immature planting were badly attacked by *O. rhinoceros*, especially the boundary palms. Two rows of vane traps were set up to evaluate the bioefficacy of AP in the mass trapping of *O. rhinoceros*. A total of ten traps were arranged with five traps on the immediate boundary between

TABLE 1
EFFECT OF FOUR TRAP DENSITIES ON THE NUMBER OF BEETLES CAUGHT IN 14 WEEKS

| *Treatments* | *Total beetles caught* | *Mean/trap* |
|---|---|---|
| 5 traps in 10 ha = 1 trap per 2 ha | 978 | 196 |
| 9 traps in 9 ha = 1 trap per ha | 1 268 (1409) | 142 |
| 18 traps in 9 ha = 2 traps per ha | 1 737 (1930) | 97 |
| 26 traps in 5.2 ha = 5 traps per ha | 1 720 (3307) | 66 |

( ) : Values adjusted to 10 ha

the five-year and one-year- old plantings spaced at fifteen rows apart. The second series of five traps were placed sixteen palms inside the palm rows, perpendicular to the field boundary. The beetles caught were sexed and their number recorded at weekly intervals. The AP sachets were replaced when the number of beetles caught decreased to zero or very low number.

The early results showed that many beetles that bred outside the mature replanting were successfully caught by the ten vane traps. The total of 245 beetles (132 females and 113 males) were caught in five weeks. The mean number of beetles caught per trap per week declined from 7.3 in the first week to 3.3 in the fifth week. The mean value over the five weeks was 4.9 per trap per week.

## EFFECT OF MASS TRAPPING ON THE REDUCTION OF DAMAGE

The effect of mass trapping on the reduction of damage was also monitored in a series of experiments. Monitoring plots (1 row in 5 rows, or 1 row in 10 rows, or 5 rows x 10 palms) were established and damage assessments were conducted periodically by marking the fresh damage/old damage using paint to avoid recounting. In general, observation of palm recovery from damage was noted in each case.

The results are briefly summarised in *Table 2*. In general, good reduction of damage was observed in five out of six sites where the mean beetle catch was less than 10 beetles per trap per week at a trap density of one trap for every 2 hectares. Poor control was recorded in Paloh areas where beetle catch was 15.3 beetles per trap per week. This gives some indication that the benefit of mass trapping with AP depends on the existing beetle population *i.e.* it was effective in low population and ineffective in high population.

## DISCUSSION

This series of ten experiments and commercial evaluation have shown that the AP was highly effective for mass trapping of rhinoceros beetles. The results of these experiments showed that the black colour vane trap was effective for trapping at the optimum density of one trap per 2 hectares It needs to be recorded here that the suggestion of using vane trap was provided by Hallett (1995). On the contrary, Ho (1996) reported no difference in the number of beetles trapped using non-painted or the black colour vane.

The reason for switching from the replacement of AP sachets at twelve weeks to eight weeks sachets was not known as it was

TABLE 2
SUMMARY TO COMPARE MEAN BEETLE CATCH AND THE OVERALL REDUCTION OF DAMAGE CAUSED BY *O. RHINOCEROS*

| *Place* | *Crop residue management* | *Age (yr)* | *Area (ha)* | *No. of traps* | *Beetle/trap/ week* | *Reduction of damage* |
|---|---|---|---|---|---|---|
| Teluk Intan | F, C | 2 | 32 | 16* | 8.29 | Good |
| Kapar | U, W | 2 | 28 | 14* | 5.72 | Good |
| B. Berjuntai | U, W | 3 | 40 | 57* | 3.85 | Good |
| Paloh | F, C | 1 | 354 | 177* | 15.30 | Poor |
| Teluk Intan | F, C, PB | <1 | 98 | 48* | 1.89 | Good |
| Jeram | Adjacent to F,C | 5 | - | 10 | 4.90 | Good |

* 1 trap/ 2ha ** based on actual counting of damage symptom and overall visual assessment

F = felling C = chipping U = underplanting W = windrowing PB = partial burning

determined by the supplier (Oechlslager of Chem Tica). This would increase the labour input in the monitoring of trapping success and more frequent changes required. It was also obvious that the effective period of release varied from six to ten weeks for the average of eight weeks. This variation occurred probably as a direct result of fluctuating temperature during the day.

The method of Mark, Release and Recapture Techniques was not a successful method to estimate beetle population using the AP. Almost all the beetles caught, marked, and released, failed to be recaptured (Ebor Research, unpublished). Similar experience of low success in retrapping of beetles has been reported by Ho (1996). Therefore the mean number of beetles caught per trap per week (at 1 trap per 2 ha density) can be used as a reasonable estimation of the beetle population in a particular area. The summary in *Table 2* indicates that mass trapping with AP was effective in the reduction of damage at low population *i.e.* probably ten beetles per trap per week and below. If that is true, no additional control measures are required.

The benefits of mass trapping over the conventional carbofuran granules application are compared (Seeveneserajah, 1995) in *Table 3.*

Therefore, in areas with low beetle population (can be determined by estimating mean beetle / trap / week), the mass trapping using AP sachets in vane traps at one trap per 2 hectares is 31 per cent cheaper *i.e.* RM102.85 per hectare compared to RM148.73 per hectare, and 86 per cent less in labour requirement *i.e.* 102 names per year compared to 732 names per year.

In practice, low beetle population has been observed in cocoa to oil palm replanting and rubber to oil palm replanting where minimum crop residue are left behind in the field. Mass trapping using AP have been reported to give good control of rhinoceros beetles and reduction of damage on immature palms in these replanting (Rajaram, 1996; Keu, 1996). This could be the result of minimum or zero infield breeding and some beetles caught were largely immigrating from external sources in search of food and breeding sites.

In large 5 hectares block monitoring experiment, it has been found that eleven to

TABLE 3
COST COMPARISON BETWEEN MASS TRAPPING WITH AP AND CONVENTIONAL CARBOFURAN APPLICATION OVER 354 HA ON A 1-YEAR-OLD OIL PALM PLANTING

| *Mass trapping with AP at 1 vane trap/2 ha with sachets renewed at 8 weeks* | *Cost (RM)* | *Carbofuron application to spear* | *Cost (RM)* |
|---|---|---|---|
| Wooden support, bucket and vanes | 7 080 | Carbofuran cost (354 ha 140 palm x 30 g x 12 mths) = 17 842 kg x RM 1.70 | 30 331 |
| Installation | 1 014 | | |
| AP sachets (177x6) @ RM25 | 26 550 | Labour cost (RM20 x 732 names) | 14 640 |
| Monthly monitoring | 1 764 | Tractor cost | 7 680 |
| Total | 36 408 | Total | 52 651 |
| RM/ha/year | 102.85 | RM/ha/year | 148.73 |
| Labour (names) | 102 | | 732 |

twelve months after felling /chipping and felling/ windrowing, the damage on immature palms was low (Ebor Research, unpublished) and this could be due to low beetle population *i.e.* those immigrating from outside to oviposition and few emerged from infield breeding. The early results of commercial evaluation in Teluk Intan indicated the possibility of early trapping to prevent damage on palms. The effectiveness in trapping out beetles flying in search of food/ oviposition and subsequent reduction in grub breeding/emergence of new generation of beetles remains to be determined. Ho (1996) reported that AP failed to effectively trap out beetles in high population areas, and other control measures had to be applied to effect integrated management of this serious pest.

Similarly low damage was recorded from twenty-four to thirty months after felling/ chipping and felling/windrowing, and low beetle population could have occurred at the end of the decomposition of crop residues. The evaluation in three-year-old planting near Batang Berjuntai has shown that mass trapping was effective in the reduction of damage.

Serious damage and large proportion of palms (up to 100%) were attacked by rhinoceros beetles from twelve to twenty-four/thirty month duration and this period coincided with grub breeding (and possible beetle emergence) (Ebor Research, unpublished). Young palms can be effectively protected by two-weekly spraying of synthetic pyrethroids (Chung, Sim & Tan, 1993; Ho, 1996). The fortnightly spraying of cypermethrin at 0.1 per cent a.i. amounted to RM7.04 per hectare per round inclusive of labour and chemical costs, giving a total cost of RM168.96 per hectare per year at twenty-four rounds of spraying (Kumaran, 1996). However, some beetles escaped to neighbouring fields causing serious damage to the spears and subsequent newly opened fronds of mature palms. Spraying onto taller mature palms could be difficult and power spraying equipments are required. In such situation, mass trapping along field boundary in five-year-old planting near Jeram has been shown to successfully reduce damage on spear/fronds.

A good alternative package of IPM has been reported by Ho (1996). This involves the proper management of crop residue (planting of legume cover crops, pulverisation of chips), mass trapping of beetles using AP + infecting beetles with pathogens of viral and fungal diseases + release infected beetles to start an epizootic in breeding sites, and the monthly spraying of synthetic pyrethroid to protect immature palms in the field. The entire package will cost about RM256.90 per hectare per year. It is most suitable for IPM of rhinoceros beetles in zero burning environment.

## CONCLUSION

It is now obvious that the AP sachets are effective for mass trapping of rhinoceros beetles. At the same time, the limit of its application to reduce damage has been apparent as it fails to work in high beetle population areas. More work is required to further quantify the upper limit of its use *i.e.* perhaps fifteen beetles per trap per week.

The AP is therefore recommended for mass trapping in order to achieve cost-effective control of rhinoceros beetles in low population areas. It can also be used effectively in IPM packages, for removal of beetles, monitoring of beetle population, and spreading infected beetles to start an epizootic.

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