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Effect of Abiotic Factors on the Efficiency of Rhinoceros Beetle Pheromone, Oryctalure in the Oil Palm Growing Areas of Andhra Pradesh

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Managing the rhinoceros beetle using aggregation pheromones as one of the tools of IPM is commonly practiced in all the oil palm growing areas. The aggregating pheromone, oryctalure (Sime RB pheromone) is responsible for effective trapping of beetles. The total beetles trapped are a function of the longevity of the pheromone sachet and the emergence of beetles (depending on amount of breeding material available). High day temperatures (maximum temperatures) exceeding 33.5°C affected the longevity of the pheromone and ultimately reduced the beetle catch. Slight increase in temperature reduced the efficacy of the lure. Both relative humidity and night temperatures did not cause any effect on the pheromone activity. Rise in day temperatures could cause fast evaporation of the pheromone that ultimately affected the longevity of the material. Relative humidity had positive response in attracting the beetles into the trap but the existing maximum temperatures nullified the effect of the former in increasing the beetle catch. The bucket trap using vanes was not effective in complete trapping of the attracted beetles allowing them to skip. These skipped beetles increased the per cent infestation on the surrounding palms of the trap. Methodology on trapping the skipped beetles needs to be developed. However, the longevity of the lure varied according to the prevailing atmospheric conditions with longer field life in winter and shorter in summer. Weather conditions of a given area played a direct impact on the number of beetles trapped. Though the pheromone and the trap were effective in trapping the beetles, but high temperatures could reduce the effectiveness. Cost benefit ratio for the pheromone trap and the number of beetles trapped was found uneconomical in the coastal areas of Andhra Pradesh under the existing atmospheric conditions. However, these can be utilised for dissemination of the other biological agents particularly the virus, Baculovirus oryctes.

Keywords: *Oryctalure, rhinoceros beetle, coastal areas, Andhra Pradesh, oil palm*

Oil palm is a wild perennial palm of West Africa origin. It has been introduced into India for increasing the vegetable oil production of the country and thereby to save the foreign exchange content on the importation of vegetable oil as well as attaining the self sufficiency in native oil production. Because of its high productivity of 4-6 tonnes of oil per hectare per year, the Government of India has promoted its cultivation in a big way in the irrigated tracts of coastal areas of Andhra Pradesh.

The major pest of oil palm plantations in this area is rhinoceros beetle, which is migrating from coconut and Palmyrah palms. Bedford (1980) and Wood (1968a) reported the documentation of the importance of rhinoceros beetle in South East Asia on coconut and oil palm. The pest was reported to set back coconut cultivation in Samoa for 60 years (Marshall, 1978) and bring about 60 per cent decrease in oil palm yield in the first year of harvesting (Liau & Ahmad, 1991). Heong (1981) classified the rhinoceros beetle as Kstrategist within the r-K continuum of ecological strategies of pests (Southwood, 1977). In Malaysia the commercially viable methods of control of rhinoceros beetle damage to oil palm have traditionally been centered on cultural and chemical means. Destruction of breeding grounds by burning is most effective but unable to continue due to environment protection act. Though growing of thick legume crop as ground cover over breeding sites is very useful as demonstrated by Wood (1968b) but it may not be possible in small scale areas in the Andhra Pradesh as it needs lot of motivation. Use of barbed wire to extract the beetles from the spindles of the infested palms is labourious and troublesome (Bedford, 1980). Although physical destruction of breeding grounds and racking the farm yard manure (FYM) pits is the most effective method to control the beetle population (Mohd Hashim *et al.*, 1993) but not being followed in letter and spirit. The most commonly used practice of placement of carbofuran granules (Toh & Brown, 1978) and naphthalene balls (Gurmit Singh, 1987) in the spindles were nevertheless reported to provide inadequate control and found ineffective (Samsudin *et al.*, 1993).

Norman *et al.* (1999) recommended the rhinoceros aggregation pheromone, ethyl 4-methyloctanoate to lure the beetle adults by keeping one trap for every 2 ha of planted area. The important features of pheromone trapping are to monitor the beetle activity and detect its presence in pest free areas, to mass trap the beetle in hot spots and destroy the floating population, to assess the population levels of the pest and to disseminate the microbial control agents that feed on the beetle and control the pest. Hence pheromone trapping of beetle is ecologically safe and environmentally friendly tool in the IPM.

However the longevity of the lure may vary according to the prevailing atmospheric conditions. The lures show longer shelf life in winter and shorter in summer. Weather conditions of a given area have a direct impact on the number of beetles caught by the pheromone traps. High beetle populations are obtained when moderate weather conditions prevail *i.e.* when it is neither too hot nor too cold. Uniform beetle captures can be obtained with moderate weather conditions with high humidity. Drop in beetle captures is commonly seen during heavy monsoon and high temperatures. These conditions are very well observed in the coastal areas of India where oil palm is being cultivated in large areas particularly in the coastal belt of Andhra Pradesh. Ho (1996) reported that effectiveness of trapping is more dependent on pheromone charge levels of the sachets. The pheromone sachets that are supplied by Chemtica Internacional S.A. of Costa Rica *i.e.* Sime RB pheromone are designed to dispense the pheromone for about two months period. The present study was conducted in the coastal area of Andhra Pradesh using Sime RB pheromone to find the effect of different abiotic factors on the beetle trapping.

METHODOLOGY

The experiment (layout - *Figure 1*) was conducted in a five-year old oil palm garden of 5 ha located at the National Research Centre (NRC) for oil palm, Pedavegi, West Godavari district of Andhra Pradesh. The breeding sites for rhinoceros beetle in the experimental area are farm yard manure (FYM) pits located in the adjacent private gardens of coconut and oil palm, compost pits of nearby village, dead logs of adjacent coconut garden, mesocarp waste of oil palm fresh fruit bunches (FFB) and empty fruit bunches (EFB) of oil palm piled

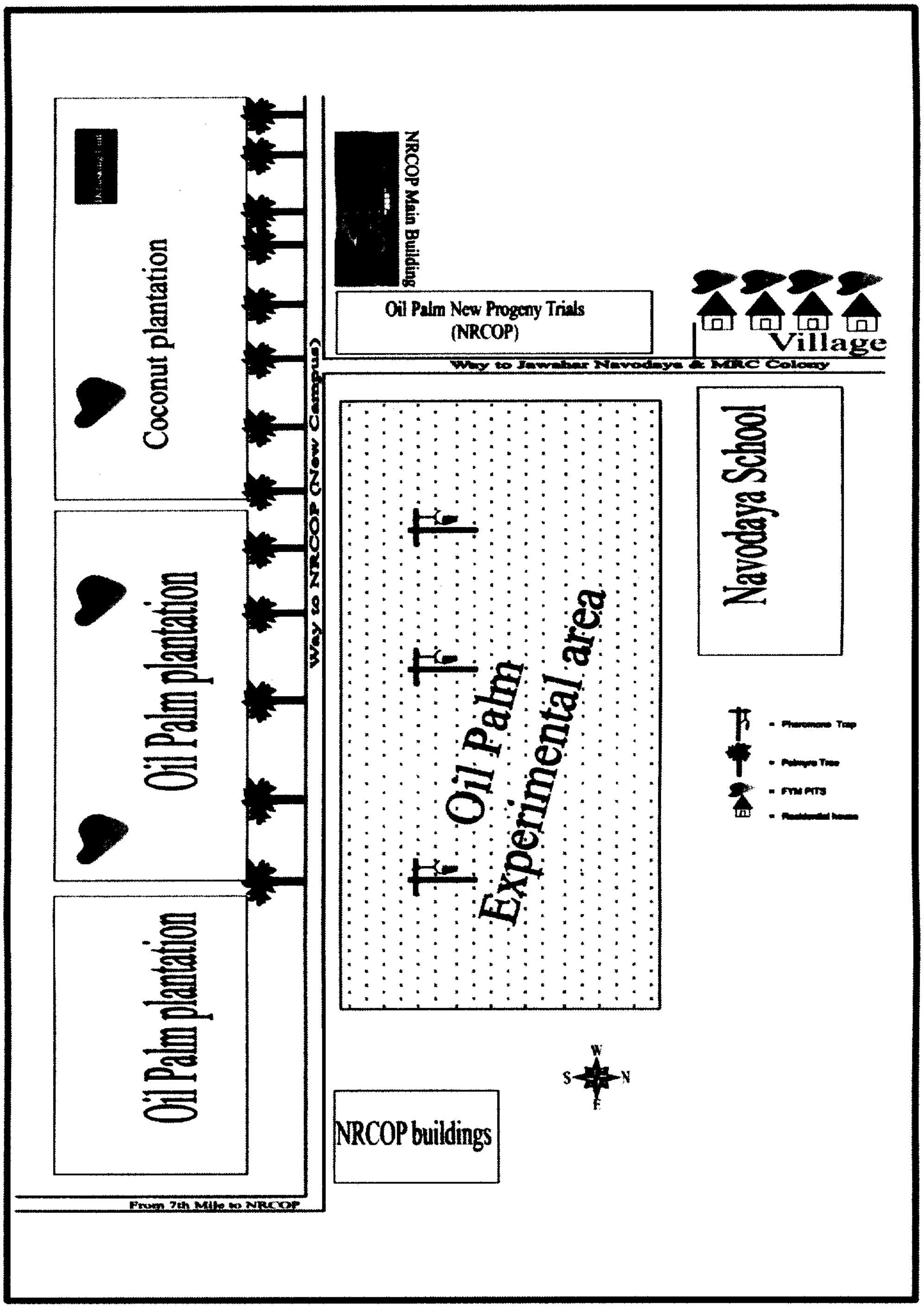

Figure 1 Layout of the experiment

up to use it as mulch in the basins of oil palm plants, organic matter accumulated in the interspaces of leaf buts and stem portion of oil palm plantations, heaps of oil palm cut leaves and young Palmyrah palms located on the road side bunds. The vane trap (*Figure 2*) was made of a 15-litre plastic bucket. The trap was hung at a height of 10 ft from the ground, which is on par with the height of the spindle leaf of the palms. The pheromone material obtained in the form of polythene sachet from M/s Chemtica Internacional, Costa Rica, South America comprising 700 mg of chemical was tied at the interlocking space of the crossed vanes (45 cm ht) made up of galvanised iron kept inside the bucket. Phago-stimulants like leaf petioles of oil palm plant were cut into pieces and kept as food baits inside the bucket and were replaced at weekly intervals. These were regularly added to the bucket to allow the beetles to feed and stay inside. This was also to avoid the chances of repetition of trapping the same beetle. Since it is essential to have a uniform release of chemical in the field in order to maintain the efficiency of the trapping programme, efforts were taken to replace the exhausted lures with fresh ones whenever it is exhausted. Weekly count of beetles trapped was recorded at fixed intervals and then monthly averages were calculated.

Traps were kept at the rate of one per 2.0 ha plantation and were inspected daily for the first 20 days, then onwards the frequency was made at weekly intervals. Three traps were erected in the experimental field area of 5 ha. Per cent infestation of rhinoceros beetle (number of leaves infested divided by total number of leaves found on the palm multiplied by 100) on the surrounding palms of the pheromone trap and on the far off palms (50 m away) was calculated based on the observations recorded on 20 palms at each

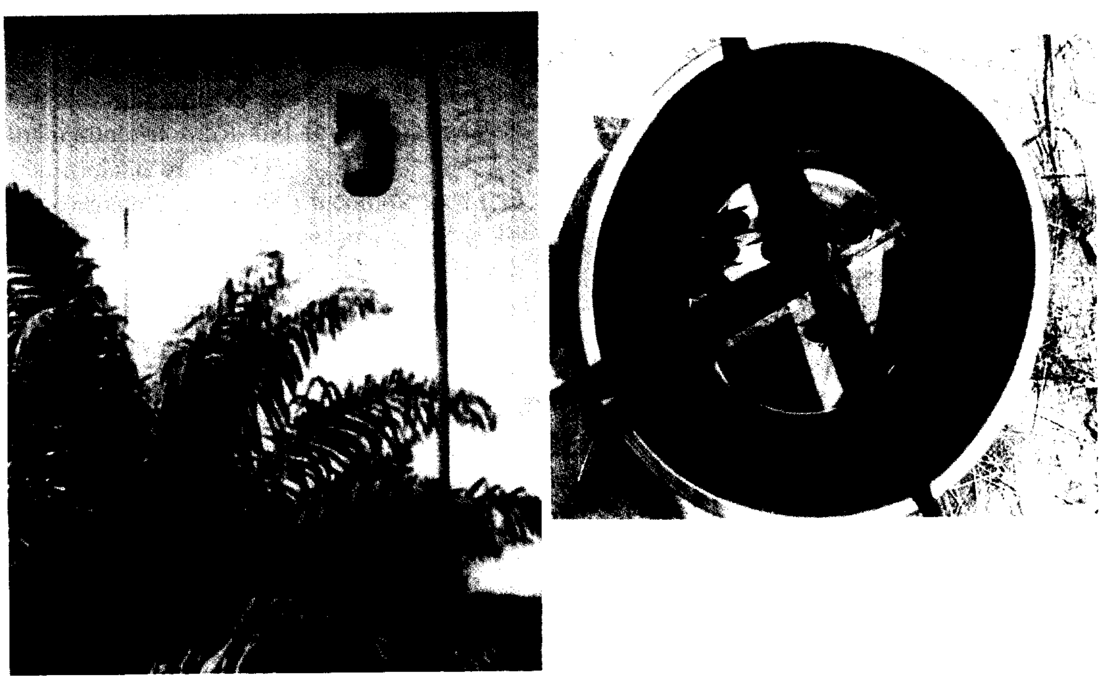

Figure 2 Longitudinal section of pheromone trap installed in the field

trap. Observations were also recorded on number of beetles trapped on each inspection. Beetle winkling was recorded in the trap installed plots at fortnightly interval (Henderson & Tilton, 1955). Correlations were made with the weather conditions namely the maximum and minimum temperatures and relative humidity.

RESULTS AND DISCUSSION

Observations on the beetles trapped into pheromone buckets were regularly recorded in the experimental site where these were hanged. Monthly weather data was collected to draw the correlation and regression equations and to arrive at the factors influencing efficiency of the trap in attracting the beetles and are given in *Table 1*.

From the table, it is seen that the beetle catch was observed to be more during the monsoon months with a peak (22.72) during September followed by January (21.0) coinciding with maximum temperature of 33.5 and 30°C respectively. The relative humidity was recorded at 80 and 67.66 per cent during the above peak periods.

In the summer months of March to July, 2001 the beetle catch was recorded at its lowest ranging between 1.87 during June to 4.92 during May. During these months atmospheric temperatures were recorded above 33.5°C varying between 33.7 to 38.16°C. Relative humidity however did not show any peak and hence there was no scope to find its effect on the beetle catch. Similar results were also observed in the regression analysis carried out between the beetle catch and atmospheric conditions. Minimum temperature did not show any significant effect on the beetle catch either in the peak or in lean periods of beetle attack.

From the above observations it is found that the beetle activity was more during August to February and was less during the remaining months. During these active periods the day temperature was below 33.5°C. The beetle catch drastically came down with the increase of temperature above this limit indicating that

TABLE 1

NUMBER OF BEETLES (TOTAL BEETLES / 3 TRAPS) TRAPPED IN THE PHEROMONE BUCKETS AND THE ATMOSPHERIC CONDITIONS THAT EXISTED IN THE EXPERIMENTAL SITE

Year and month	*Number of beetles trapped*	*Temperature °C max.*	*Temperature °C min.*	*Relative humidity (%)*
January, 2001	21	30	25.11	67.66
February	11.68	31.88	24.7	68.66
March	4	33.84	26.58	66
April	4.5	35.15	30	76.36
May	4.92	38.16	31.89	73.78
June	1.87	35.6	33.83	64.2
July	4.5	33.7	29.6	70.8
August	9.35	32.66	30.89	73.34
September	22.72	33.5	29.76	80
October	20.25	32.8	30.9	75.89
November	19.6	32.5	30.7	70.77
December, 2001	18.8	31.32	27.8	66.98

the maximum temperature of 33.57°C is the critical limit for the efficacy of the pheromones. Slight increase in temperature affected the trapping efficiency. This could be due to the following reasons.

- The pheromone material might have evaporated too fast from the sachet during the months of March to July, when maximum temperature was more than 33.5°C and thus could not pass on to the long distances and hence failed to attract the beetles. When there was any change in the above said factors, the trapping efficiency of the pheromone sachet reduced drastically. This was clearly observed with the regression model analysis carried out between the number of beetles trapped and abiotic factors namely maximum temperature, minimum temperature and relative humidity.
- It indicates that among the various weather conditions correlated for the efficacy of the pheromone, only maximum temperature showed individual effect on the beetle catch. The remaining factors namely minimum temperature and relative humidity did not cause any effect on the efficacy of the pheromone. It is seen from *Table 2* where the peak beetle catch was even observed at both low and high relative humidity.

The results drawn on regression coefficient analysis for the beetle catch and abiotic factors are given in *Table 3*.

The regression equation developed is as follows:

$$Y = 47.467 - 3.213\,X1 + 0.79973X2 + 0.4997X3 \quad (1)$$

R square = 0.468861

Adjusted R = 0.324005

TABLE 2

RELATIONSHIP OF TEMPERATURE AND RELATIVE HUMIDITY ON THE BEETLE CATCH

Sum of beetles	*Temperature (maximum)*												
Relative humidity	*30*	*31.32*	*31.88*	*32.5*	*32.66*	*32.8*	*33.5*	*33.7*	*33.84*	*35.15*	*35.6*	*38.2*	*Grand total*
64.2											1.87		1.87
66									4				4
66.98		18.8											18.8
67.66	21												21
68.66			11.68										11.68
70.77				19.6									19.6
70.8								4.5					4.5
73.34					9.35								9.35
73.78												4.92	4.92
75.89						20.25							20.25
76.36										4.5			4.5
80							22.72						22.72
Grand total	21	18.8	11.68	19.6	9.35	20.25	22.72	4.5	4	4.5	1.87	4.92	143.19

TABLE 3
REGRESSION ANALYSIS ON BEETLES TRAPPED AND ABIOTIC FACTORS

Regression	*Coefficient*	*S.E.(m)*	*t-stat*	*P-value*
Beetles trapped	47.76	26.40	1.80	0.09
Temperature (max)	-3.2113	0.84	-3.81	0.002
Temperature (min)	0.499	0.708	0.705	0.494
Relative humidity	0.799	0.308	2.594	0.024

Where:

Y = Number of beetles trapped
X1=Maximum temperature
X2=Relative humidity
X3=Minimum temperature

As seen from regression equation (1), the number of beetles trapped decreased at the rate of three for every one-degree increase in maximum temperature whereas relative humidity recorded positive effect on number of beetle trapped. As seen by the *"t"* value, the minimum temperature did not show any significant effect on number of beetles trapped.

Observations on per cent infestation of the rhinoceros beetle in and around the pheromone traps were collected to find out the effect of baiting on the pest infestation (*Table 4*). The per cent infestation of the beetle was calculated based on the number of leaves infested divided by total number of leaves present on each palm multiplied by 100.

The hole made by the pest in the spindle region was observed acting as passage for bud rot fungus. This resulted into bud rot disease, which led to mortality of the palm. But many times the infected palms were found surviving without any treatment. However the growth

TABLE 4
RHINOCEROS BEETLE INFESTATION (%) IN AND AROUND THE PHEROMONE TRAPS

Month and year	*Rhinoceros beetle infestation (%) (Average of 20 randomly selected palms)*		
	Control plots	*Trapped areas*	*Number of beetles trapped*
January, 01	0.7	1.02	21
February	0.46	0.52	11.68
March	0.58	0.32	4
April	0.8	0.2	4.5
May	0	0.12	4.92
June	0	0.24	1.87
July	0.34	0.36	4.5
August	0.3	0.43	9.35
September	0.37	0.52	22.72
October	0.87	1.29	20.25
November	0.74	0.93	19.6
December	0.72	0.89	18.8

of the palm was arrested due to its attack. Occasionally red palm weevil incidence was also observed in the infested palms, which also entered through this hole. On the adult palms, rhinoceros beetle infestation did not cause any direct effect on the yield losses. Though the pest infestation reduced the photosynthetic area, due to the emergence of 2.3 new leaves (on an average) per month in the irrigated tracts of Andhra Pradesh made the palm to compensate the loss. The research findings of the Malaysian Palm Oil Board reveal that maintenance of 40-48 fronds on peak yielding palm of 8-14 years is the optimum to get higher yields (Suboh, 2001). Hence it is clear that unless the infestation is very high that makes the palm to suffer with less than 40 fronds to exist at any time only then the yield losses may arise. To achieve this infestation large number of beetles should be present which is not the case in the present condition as observed in *Table 4*.

It is also observed that the beetle infestation was heavy during the months of September to February with a peak during October. These results coincide with that of the beetles trapped. This indicates two statements

i. In general the beetle incidence is more during the above mentioned period
ii. All the beetles, which were attracted to the trap did not fall inside. Those, which failed to fall due to reasons unknown, attacked the palms adjacent to the trap causing infestation.

Regression analysis was carried out to find out the effect of abiotic factors and beetles trapped on the per cent infestation of the rhinoceros beetle in the pheromone trap experiment and are given in *Table 5*.

The regression equation drawn is as follows

$$Y = 20.21 + 0.029\,X1 - 0.041\,X2 + 0.019\,X3 - 0.014X4 \quad (2)$$

R square = 0.613261464
Adjusted R = 0.458566049

Where

Y = Per cent infestation
X1 = Number of beetles trapped
X2 = Maximum temperature
X3 = Minimum temperature
X4 = Relative humidity

As seen from regression equation (2) the per cent infestation of rhinoceros beetle increased at the rate of 0.029 for every one beetle trapped whereas maximum temperature was found showing negative effect. As seen by the "*t*" value, all the abiotic factors show non-significant effect in increasing the per cent infestation.

The cost benefit ratio of various treatments used for the control of rhinoceros beetle including pheromone trapping was studied by comparing the per cent infestation before and 45 days after the initiation of the treatments

TABLE 5
REGRESSION ANALYSIS ON (%) INFESTATION *VS.* BEETLES TRAPPED AND ABIOTIC FACTORS

Regression	*Coefficients*	*Standard error*	*t stat*	*P-value*
Percent infestation	2.021	1.541	1.311	0.219
Number of beetles	0.029	0.015	1.932	0.082
Temperature (max)	-0.041	0.065	-0.633	0.540
Temperature (min)	0.019	0.037	0.524	0.611
Relative humidity	-0.014	0.020	-0.737	0.477

and are given in *Table 6*. From the table it is observed that the infestation has come down in both the granular insecticides as well as the bioagent, *Metarhizium anisopliae* treated palms. However, the emulsifiable concentrates which were applied in the crown portion were able to stop the infestation from further increase. These results are in accordance with the results reported by Chung *et al.* (1991) and Ho (1996). The efficacy of *Metarhizium anisopliae* against the rhinoceros beetle was reported by Tey and Ho (1995) indicating the need for high amounts of inoculum. The present studies of crown application of *Metarhizium anisopliae* spores gave positive results on the commercial use of the fungus, which is very effective in controlling the pest and inexpensive in terms of cost of application as compared to other traditional practices. However pheromone applied plots could not resist the infestation from the initial levels but was further increased. Ho (1996) observed no clear cut suppression of rhinoceros beetle damage in the pheromone trapping plots and reported that continued presence of beetles on palms in the pheromone trap installed plots is the indication of the unsuccessful trapping out of beetles which are in conformity with the present results. The monetary benefit that could be obtained by way of application of the above treatments is more in case of bioagent *Metarhizium anisopliae* followed by granular insecticides, little in case of emulsifiable concentrates but was rather negative with the pheromone treatments.

CONCLUSION

The efficiency of the rhinoceros beetle pheromone, *oryctalure*, obtained from Chemtica Internacional, Costa Rica was very inferior in the oil palm growing areas of coastal Andhra Pradesh and accordingly the cost benefit ratio was very much less. Existence of high temperatures in the coastal areas has detrimental effect in trapping the beetles and

TABLE6
COST OF DIFFERENT TREATMENTS APPLIED AND THE PER CENT CONTROL OF RHINOCEROS BEETLE

Sl.no.	*Treatment*	*Cost of the treatment/ha/yr US$*	*Infestation (%)*	
			Before the initiation of the treatments	*45 days after the application*
1	Granular insecticides (Phorate 10G; Cartap hydrochloride 4G and Carbofuran 3G)	17.91	0.49	0.16
2	Emulsifiable concentrates (Phosphamidon 85% and Monocrotophos 36%)	35.75	0.24	0.24
3	*Metarhizium anisopliae* ($1.9 X 10^4$)	4.16	0.66	0.00
4	*Pheromone* (1 trap per ha)	22.5	0.45	0.53

thereby making the pheromone ineffective. Similar observations were recorded in the previous years also. Although the role of polybag, wherein pheromone material was impregnated, on the pheromone efficacy is not tested, the high temperatures must have hastened the evaporation, which resulted, in poor catch of beetles.

Relative humidity, though showing positive response in attracting the beetles into the trap but the existing maximum temperature nullified the effect of the former in increasing the beetle catch. Hence pheromone mass trapping for rhinoceros beetle was observed to be ineffective in this region.

The results show that though the pheromone baits attract the beetles, but due to insufficient trapping methods, the missed/ skipped beetles cause an increase in infestation which could have been avoided if the traps were not placed. In other words, the traps cause damage rather than control the pest. At the same time the efficiency is entirely dependant on the ecological conditions of the area. Methodology on trapping the skipped ones needs to be developed. If 100 per cent population that have been attracted to the trap are fallen, only then the efficacy of the pheromone can be determined otherwise it will be an extra burden to the farmers. These results are in accordance with the observations reported by Ho (1996) with no clear suppression of *O. rhinoceros* damage in the pheromone trapping plots in Malaysia confirming the present results.

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