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Analysis of the efficacy and cost-benefit ratio of different management practices against rodent damage in prevailing coconut plantation

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Abstract
Rodents are serious non-insect pests in some coastal areas of Odisha damaging green tender nuts of coconut palms. Roof rat, *Rattus rattus* L. is the most dangerous rodent species that cause a hole near the perianth region of tender nuts and drink the water content. A survey was conducted in some areas of Coastal Odisha during the year 2015-2016 to know the per cent rodent infested palms and nut damage. Field evaluation of various management practices against rodent damage (Crown baiting with bromadiolone (0.005%) wax blocks, trunk banding with polyester slippery sheet, trunk banding with G.I sheet, trunk banding with polyethylene sheet and untreated check) revealed that all the treatments gave excellent control of nut fall during the 10 months of study. The highest per cent reduction in nut fall over pre-treatment count as well as untreated check *i.e.* 99.86% and 99.88% was recorded in trunk banding with G.I sheet respectively followed by polyester slippery sheet *i.e.* 99.79% and 99.82% respectively. The incremental cost: benefit ratio was found to be highest in case of crown baiting with bromadiolone (0.005%) wax blocks (1:5.12) followed by trunk banding with polyester slippery sheet (1: 2.07). Thus farmers can be advised to adopt this practice for better management of rodent damage as well as for deriving high profit. Our training on various social engineering activities against rodent control was adopted by maximum farmers giving a positive impact. However further training on rodent damage and their management is required for generating awareness.

Keywords: Crown baiting, trunk banding and benefit-cost analysis

1. Introduction
The coconut palm (*Cocus nucifera* L.) considered as the “King of palms” and “Nature’s super market” is essentially a tree of life for millions of small and marginal farmers. It is the most useful palm in the world. Every part of the tree is useful to human life for some purpose or the other. Hence, the coconut palm is endearingly called ‘Kalpavriksha’ meaning the tree of heaven.

India is the third largest producer of coconut in the world after Indonesia (1st) and Philippines (2nd). The area under coconut production in India during the year 2015-16 was reported to be 2088.47 thousand ha with an annual production of 22167.45 million nuts and productivity of 10614 nuts per ha. The four southern states *viz*., Kerala, Tamil Nadu, Karnataka and Andhra Pradesh together account for 90 percent of the total area and production of coconut and there is high variability in productivity owing to production system. The farmers of these states are destined to flourish or perish depending on the fortunes of coconut industry. Other major traditional coconut growing areas include West Bengal, Odisha, Goa, Puducherry, Maharashtra and the island territories of Lakshadweep and Andaman and Nicobar. According to Coconut Development Board, GOI (2015-16), Odisha contributes in production of 328.38 million nuts from area of 50.91 thousand ha with a productivity of 6451 nuts per ha.

Though various measures for rodent control like trapping, banding of tree trunks, use of rodenticides and repellants are available, the major problems in their implementation are general neglect, a lack of awareness of economic losses, small land holdings which make rodent control campaigns difficult to organize over large areas, the low education and economic level of farmers and discouragement due to the frequent failure of rodent control operations as a result of the adoption of the wrong procedures of bait formulation and application (Malhi 1998) [7].

2. Material and Methods

2.1 Experimental Site

The experiment was conducted in coconut orchards of Biraramchandrapur, Sakhigopal, Puri which is situated at 19º 58' 0" North latitude and 85º 49' 0" East longitude with an altitude of 19m above mean sea level (MSL) and at 21.5 km west of Bay of Bengal. The hottest month is May, with an average temperature of 30.4ºC. Most precipitation falls in the month of August, with an average rainfall of 304 mm.

2.2 Experimental details and layout

Orchards with high rodent infestation rates were selected. The trial was conducted in a randomized block design (RBD) with five treatments and four replications, where each farmer represented one replication. One plot consisted of forty coconut trees.

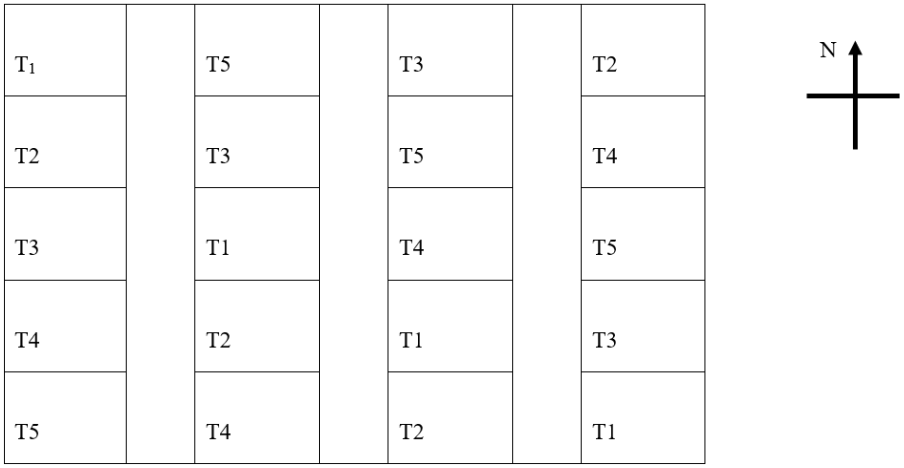

Fig 1: Experimental Layout

2.3 Details of the treatments

Table 1: Treatments used in experiment

Treatment No.	Treatment Details
T_1	Crown baiting with Bromadiolone (0.005%) wax block @ 2 blocks/plant twice a year (30-35g) one on each side of the crown bearing tender nuts.
T_2	Trunk banding with specially designed polyester slippery sheet (45 cm width) at a height of 1.5 m.
T_3	Trunk banding with G.I sheet/zinc sheet (45 cm width) at a height of 1.5 m.
T_4	Trunk banding with polyethylene sheet (45 cm width) at a height of 1.5 m.
T_5	Untreated check

Crown cleaning of the coconut trees was done before implementation of each treatment

2.4 Implementation of treatments

Crown baiting with bromadiolone (0.005%) wax block

The crown of the palms selected for crown baiting were cleaned. The wax blocks were inserted with thread at the centre and placed, one on each side of the crown. The procedure was again repeated after 6 months.

Trunk banding

The crown of the palms selected for banding were cleaned properly. The overlapping fronds were trimmed to restrict the movement of rats from one palm to the other. Polyester slippery bands of 45 cm width were banded around the tree trunk at a height of 1.5m. A similar procedure was followed for trunk banding with G.I sheet and polyethylene sheet.

2.5 Data recording

The observation on fallen damaged nuts was taken on each coconut tree at one week before implementation of treatments during morning hours. After one week of pre-treatment count, the treatments were implemented. The observation on fallen damaged nuts was taken at 2, 4, 6, 8 and 10 months after implementation of treatments. Then the nut fall reductions over pre-treatment count as well as over untreated check in per cent basis were calculated.

2.6 Cost-benefit analysis of the treatments

The nut yield of 40 plants per acre was recorded from each farmer which was then converted to nut yield per hectare. Then cost benefit analysis was done considering nut yield and expenditure on labour charge and materials used.

$$\text{Increase in yield over control (\%)} = \frac{\text{Nut yield in treated trees} - \text{Nut yield in control palms}}{\text{Nut yield in control palms}} \text{ X } 100$$

Table 2: Details of cost of treatments implemented in coconut orchard

Sl. No.	Parameters	Values of materials/ha			
		Bromadiolone cake	G.I Sheet	Polyester slippery sheet	Polyethylene sheet
1	No of trees/ha	100	100	100	100
2	Requirement/tree	4 blocks	4.5sq.ft	4.5sq.ft	4.5sq.ft
3	Requirement/ha	400 blocks	450 sq ft	450 sq ft	450 sq ft
4	Cost/ha	400X14/- = 6000/-	450X20/-=9000	450X12/-=5400	450X3/-=1350
5	Installation charge	6000/-	3060/-	3060/-	3060/-
6	Maintenance cost	-	18000	18000	18000
6	Total cost	12000/-	30060/-	26400/-	22410/-

Size of sheet: 3.0ft X 1.5ft = 4.5sqft

3. Result and Discussion

Table 3: Efficacy of various management practices against rodent damage in coconut plantations of Biraramchandrapur, Sakhigopal, Puri during 2016-17

Tr. No.	Treatments	Pre-treatment nut fall count (PTC)	Post-treatment nut fall count							
			2 MAT	4 MAT	6 MAT	8 MAT	10 MAT	Mean	Reduction over PTC (%)	Reduction over UC (%)
1	Crown baiting with Bromadiolone (0.005%) wax block	14.15(3.83)	0.4(0.94)^{b}	1(1.22)^{b}	1.52(1.42)^{b}	0.45(0.96)^{b}	1(1.21)^{b}	0.87	93.82	94.29
2	Trunk banding with specially designed polyester slippery sheet	13.37(3.72)	0.02(0.72)^{a}	0.05(0.74)^{a}	0.05(0.74)^{a}	0.02(0.72)^{a}	0.0(0.71)^{a}	0.03	99.79	99.82
3	Trunk banding with G.I sheet/Zinc sheet	12.87(3.66)	0.05(0.74)^{a}	0.02(0.72)^{a}	0.02(0.72)^{a}	0.0(0.71)^{a}	0.0(0.71)^{a}	0.02	99.86	99.88
4	Trunk banding with polyethylene sheet	12.95(3.67)	2.4(1.70)^{c}	4.97(2.34)^{c}	6.25(2.60)^{c}	6.47(2.64)^{c}	7.05(2.75)^{c}	5.43	58.08	64.56
5	Untreated check (U.C)	13.65(3.76)	14.42(3.86)^{d}	13.8(3.78)^{d}	15.32(3.98)^{d}	16.77(4.16)^{d}	16.92(4.17)^{d}	15.45	-	-
S.Em (±)		0.06	0.06	0.05	0.04	0.04	0.03	-	-	-
CD (P=0.05)		NS	0.18	0.14	0.13	0.11	0.11	-		

MAT- Months after Treatment; NS- Non-significant; Figures in the parenthesis are (X+0.5) square-root transformed values

The results on the efficacy of some management practices against rodent damage have been presented in Table 1. One week before implementation of treatments the average nut fall varied from 12.97 to 14.15 fallen nuts on all the palms under observation. At 2 months after implementation of treatments, T_2 i.e. trunk banding with polyester slippery sheet was significantly superior (0.02 fallen nuts) followed by T_1 i.e. trunk banding with G.I sheet (0.05 fallen nuts) in controlling the nut damage. T_2 and T_1 were found to be statistically at par with each other. Among all the treatments T_4 i.e. trunk banding with polyethylene sheet was proved inferior (2.4 fallen nuts) in controlling the nut damage.

At 4 months and 6 months after implementation of treatments, T_3 was found to be significantly superior (0.02 fallen nuts) followed by T_2 (0.05 fallen nuts) in controlling nut damage and both the treatments were statistically at par with each other. Among all the treatments T_4 was again found to be inferior (4.94 fallen nuts and 6.62 fallen nuts respectively) in controlling the nut damage.

A similar trend was observed with regard to nut fall at 8 months after implementation of treatments. T_3 proved to be most superior with zero nut fall followed by T_2 (0.02 fallen nuts) in controlling nut damage. Both the treatments were statistically at par with each other.

At 10 months after implementation of treatments both T_2 and T_3 were superior in controlling nut damage with zero nut falls in both the treatments. T_4 gave the lowest control among all other treatments (7.05 fallen nuts).

The per cent reduction in nut fall over pre-treatment count revealed trunk banding with G.I sheet as the best treatment (99.86%) among other treatments followed by trunk banding with polyester slippery sheet (99.79%) and crown baiting with bromadiolone wax block (93.82%). The lowest per cent reduction in nut fall over pre-treatment count was observed in trunk banding with polyethylene sheet (56.74%).

The per cent reduction in nut fall over untreated check was also found to be highest in case of trunk banding with G.I sheet (99.88%) followed by trunk banding with polyester slippery sheet (99.82%) and crown baiting with bromadiolone wax block (94.29%). Trunk banding with polyethylene sheet had the lowest per cent reduction in nut fall over untreated check (68.43%).

The present investigation revealed that trunk banding with G. I sheet exercised better efficacy which was more or less similar to trunk banding with polyester slippery sheet (Table 1). The next better treatment was crown baiting with bromadiolone (0.005%) wax blocks. All these three treatments reduced the nut fall by more than 90%, highest being 99.86% in trunk banding with G.I sheet.

Several workers have demonstrated that trunk banding with metal bands of plain galvanized iron could effectively reduce rat damage in coconut, provided the bands are kept in good repair and the overlapping fronds are regularly trimmed. Montenegro (1962) [8] reported that a 23 cm wide plain G.I sheet wrapped around a palm trunk increased the number of harvestable nuts in study plots by 21.5% over a 5year period. Hoque (1973) [5] recorded zero nutfall in 10 banded palms and 405 fallen damaged nuts in 10 reference palms during a 17week observation. Thus our findings corroborates with the above findings. In case of crown baiting with bromadiolone (0.005%) wax blocks our findings revealed a mean nut fall of 0.4 fallen nuts at 2 months of treatment that increased to mean nut fall of 1 fallen nut and 1.52 fallen nuts at 4 and 6 months after treatment. The mean nut fall decreased to 0.45 fallen nuts at 8 months after treatment because of 2nd baiting. However, Reidinger and Libay (1980) [10] reported that rat activity and fallen, damaged nuts decreased about 2 months after baiting and remained near zero thereafter. Thus our

present finding is a deviation from the above finding.

3.2 Benefit-Cost Analysis

The cost: benefit analysis calculated for different treatments has been presented in Table 2. The highest nut yield of 7491 nuts per ha was recovered from T_3 (trunk banding with G.I sheet) followed by T_2 (7484 nuts per ha). But the highest incremental cost benefit ratio was exhibited by T_1 (1: 5.12) followed by T_2 (1: 2.07). The lowest cost benefit ratio was recovered from T_3 (1: 0.78).

Table 4: Cost: Benefit analysis of various treatments against rodent damage in coconut orchard of Biraramchandrapur during 2016-2017

Treatments	Nut yield (Nuts/ha/yr)	Incremental Yield over Control (Nuts/ha/yr)	Value of Incremental Yield (Rs)	Cost of Treatment (Rs/ha)	Profit due to treatment (Rs)	Incremental Benefit Cost Ratio
T1: Crown baiting with bromadiolone (0.005%) wax blocks	7072	4892	73380	12000	61380	5.12
T2: Trunk banding with polyester slippery sheet	7484	5304	79560	26460	53100	2.07
T3: Trunk banding with G.I sheet	7491	5311	79665	30060	49065	1.63
T4: Trunk banding with polyethylene sheet	4842	2662	39930	22410	17520	0.78
T5: Untreated Check	2180	-	-	-	-	-

Cost of nuts = Rs 15/nut, Cost of Bromadiolone wax blocks = Rs 15/block, Cost of polyester slippery sheet = Rs 12/sq.ft,
Cost of G.I sheet = Rs 20/sq.ft, Cost of polyethylene sheet = Rs 3/sq.ft, Labour charges for = Rs 30/man/palm

Though T_3 was proved to be superior over other treatments in control of nut fall, the incremental cost benefit ratio was found to be lowest in this treatment *i.e.* 1: 5.78 because of high treatment cost.

The present study indicated positive returns from each treatment during this 10month trial. However, Gallego *et al.* (1981) [4] indicated a negative return from trunk banding with G.I sheet during the first 2 years and a positive return starting in the third year. Thus the above finding does not match with the present finding.

4. Summary and conclusion

The results on evaluation of efficacy of various management practices against rodent damage revealed trunk banding with G.I sheet as the most superior treatment in controlling the nut damage that resulted in 99.86% and 99.88% reduction in nut fall over pre-treatment nut fall count and untreated check respectively. This was followed by trunk banding with polyester slippery sheet with 99.79% and 99.82% reduction in nut fall over pre-treatment nut fall count and untreated check respectively. Both the treatments were found to be statistically at par with each other. Crown baiting with bromadiolone (0.005%) wax blocks resulted in 93.82% and 94.29% reduction in nut fall over pre-treatment nut fall count and untreated check respectively. Trunk banding with polyethylene sheet proved to be better in initial months but later on the nut fall started increasing, proving the treatment as not so good for long term purpose.

The cost benefit analysis was found to be highest in case of crown baiting with bromadiolone wax blocks (1: 5.12) followed by trunk banding with polyester slippery sheet (1: 2.07). Crown baiting with bromadiolone (0.005%) wax blocks was effective in controlling nut fall above 90% (93.82%) and did not require any further maintenance unlike trunk banding. Even though trunk banding with G.I sheet and polyester slippery sheet were found to be highly effective among all other treatments, these are the least preferred methods because of prohibitive costs of material, labour and maintenance requirements.

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