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Farmer-centric evaluation of pest management practices against the rhinoceros beetle (*Oryctes rhinoceros*) in Telangana's expanding oil palm frontier

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Abstract

The rapid state-led expansion of oil palm (*Elaeis guineensis* Jacq.) cultivation in Telangana is significantly challenged by infestations of the rhinoceros beetle (*Oryctes rhinoceros*), leading to substantial economic losses. While chemical and mechanical control measures are documented, their on-ground adoption is dictated by farmer perception, practicality, and local socio-economic contexts. This study employed a participatory, farmer-centric framework to evaluate the acceptance, perceived efficacy, and constraints of three common management practices across four major oil palm-growing districts of Telangana (Gadwal, Wanaparthi, Mahabubnagar, Nagarkurnool). Data were collected through structured surveys (n=127), focused group discussions, and field validation over an 18-month period. Practices evaluated included crown drenching with lambda-cyhalothrin (@ 3 ml L⁻¹), installation of rhinoceros beetle traps, and soil application of 3G granules. Results, ranked by a composite Farmer Acceptance Index (FAI), revealed crown drenching as the most preferred (FAI: 0.89), attributed to its immediate visual effectiveness and rapid palm recovery. Beetle traps, though technically useful for population monitoring, received moderate acceptance (FAI: 0.62) due to associated maintenance labour and costs. Interestingly, 3G granules, while rated low for beetle control (FAI: 0.41), were highly valued (85% approval) for their secondary role as an effective rodent repellent, showcasing farmer adaptation to multi-pest scenarios. The study concludes that extension strategies must evolve beyond prescriptive recommendations. Sustainable adoption hinges on promoting hierarchical, need-based protocols that prioritize farmer-validated, operationally simple solutions like crown drenching for curative action, while integrating traps for community-level area-wide management and recognizing the multi-utility of interventions.

Keywords: Participatory rural appraisal, farmer perception, adoption barriers, integrated pest management (IPM), *Elaeis guineensis*, lambda-cyhalothrin, extension strategy, Telangana

1. Introduction

The agrarian economy of Telangana is undergoing a transformative shift with the strategic promotion of oil palm (*Elaeis guineensis* Jacq.) as a high-yielding, economically viable alternative to traditional crops, driven by state-led missions and assured irrigation projects (GoT, 2021)^[7]. This policy impetus has led to a remarkable expansion in the state's oil palm footprint. From a negligible base a decade ago, the cultivated area in Telangana surged to over 1.2 lakh acres (approx. 48,500 hectares) by the end of 2023, with a progressive increase in fresh fruit bunch (FFB) production (Directorate of Oil Palm Development, 2023)^[5]. This expansion is concentrated in districts with access to canal and lift irrigation from major projects like Jurala, Srisailem, and Nettempadu. Among these, the districts of Mahabubnagar, Nagarkurnool, Gadwal, and Wanaparthi have emerged as the core of the state's "oil palm frontier,"

collectively accounting for nearly 65% of the state's total acreage (Rao & Reddy, 2022)^[9].

District-wise, by 2023, Mahabubnagar led with approximately 35,000 acres under oil palm, contributing the largest share to state production. Nagarkurnool followed with about 25,000 acres, exhibiting rapid growth in its eastern mandals. Gadwal and Wanaparthi districts, though starting from a smaller base, witnessed exponential annual growth rates exceeding 20%, with areas reaching roughly 18,000 and 15,000 acres, respectively (Field Data & State Horticulture Department, 2023). This rapid monoculture expansion into a new agro-ecological zone has, however, precipitated a significant ecological backlash in the form of escalating pest incidence.

Oryctes rhinoceros (Linnaeus, 1758)^[14], commonly called the coconut rhinoceros beetle, is a large scarab beetle in the family Scarabaeidae that infests palms, especially coconut

and oil palm, by boring into the crown and feeding on young fronds, which reduces plant vigour and yield (Kalawate *et al.*, 2025)^[14]. This species is widely distributed in tropical Asia and parts of the Pacific and is recognized as a serious pest of cultivated palms due to direct damage to growing tissues and its role in weakening trees. Larvae develop in decomposing organic matter, while adults are responsible for most of the crop damage, making *O. rhinoceros* an important focus for pest management research. Recent molecular studies have provided the first DNA barcode data for this pest from the Deccan region of India, offering new tools for identification and population studies. Additionally, research has explored the potential use of beetle frass as a soil amendment, reflecting broader interest in its ecological impacts beyond pest damage (Han *et al.*, 2025)^[13].

Among the various insect pests, the rhinoceros beetle, *Oryctes rhinoceros* L. (Coleoptera: Scarabaeidae), has been identified as the most destructive pest, causing severe and often catastrophic damage to young oil palm plantations (Manjula & Sridevi, 2018)^[8]. Adult beetles bore into the crown, damaging the unopened spear leaves and the meristematic growing point. This feeding results in characteristic V-shaped notches on fronds, stunted growth, delayed flowering, and in severe cases, the death of the palm, culminating in yield losses estimated at 20-40% in the affected plantations of Telangana (Field Observations, 2022-23). Management strategies recommended in established growing regions include chemical insecticides, bio-agents like *Metarhizium anisopliae*, pheromone traps, and field sanitation (Bedford, 2013; Dhileepan, 1994)^[2, 4].

A significant disconnect, however, often exists between standardized research recommendations and on-farm adoption, a gap particularly pronounced in new agro-ecologies like Telangana where farmers are novice to the crop-pest complex (Feder & Umali, 1993)^[6]. Adoption decisions are influenced by a complex matrix of factors:

perceived efficacy, cost-benefit ratio, labour availability, operational complexity, and the immediacy of results (Rogers, 2003)^[10]. A purely techno-centric evaluation of management practices overlooks these critical socio-economic dimensions, leading to poor compliance and suboptimal pest control.

Therefore, this study posits that for sustainable pest management in an expanding crop system, understanding the farmer's perspective is not merely supplementary but fundamental. The primary objective was to conduct a farmer-centric evaluation of prevailing rhinoceros beetle management practices in the high-growth districts of Telangana. Specifically, the study aimed to: (i) assess farmer perceptions and satisfaction levels regarding the efficacy, cost, and labour input of three common interventions; (ii) identify key drivers and barriers to their adoption; and (iii) synthesize these insights to formulate a contextually relevant, farmer-validated Integrated Pest Management (IPM) framework for the region.

2. Materials and Methods

2.1 Study Area

The research was conducted from January 2022 to June 2023 in the four primary oil palm-growing districts of Telangana: Gadwal, Wanaparthy, Mahabubnagar, and Nagarkurnool. These regions fall in a semi-arid agro-climatic zone but host pockets of irrigated agriculture. Young plantations (1-4 years old), which are most vulnerable to beetle attack, were the primary focus.

2.2 Participant Selection and Demographics

A purposive sampling method was used to select 127 oil palm growers experiencing notable rhinoceros beetle infestation. Participants cultivated areas between 1 and 5 acres, representing the dominant smallholder profile in the region. District-wise distribution and basic demographics are summarized in Table 1.

Table 1: Profile of participant farmers across the study districts

District	No. of Farmers	Avg. Farm Size (Acres)	Avg. Palm Age (Years)
Gadwal	32	2.8	2.5
Wanaparthy	29	3.1	2.1
Mahabubnagar	38	2.5	2.8
Nagarkurnool	28	2.7	2.3
Total/Average	127	2.8	2.4

2.3. Evaluated Management Practices

Three management practices, commonly advised by extension agencies, were demonstrated and evaluated:

- Crown Drenching (CD):** Application of a solution of lambda-cyhalothrin 5 EC (@ 3 ml per litre of water) directly into the crown spear and leaf axils.
- Rhinoceros Beetle Traps (Trap):** Installation of bucket-type traps using pheromone lures or fermenting palm sap.
- Soil Application of 3G Granules (Granule):** Placement of carbofuran 3G granules (@ 25-30 g per palm) around the stem base.

2.4. Data Collection and Analysis

A mixed-methods approach was employed:

- Structured Surveys:** A pre-tested questionnaire used a

5-point Likert scale (1=Very Poor, 5=Very Good) to rate each practice on four parameters: Perceived Effectiveness, Economic Viability, Operational Simplicity, and Overall Satisfaction. A composite Farmer Acceptance Index (FAI) was calculated for each practice as the mean of normalized scores across all parameters.

- Focused Group Discussions (FGDs):** Six FGDs (8-10 farmers each) were conducted per district to gather qualitative insights.
- Field Validation:** Researcher observations on per cent reduction in fresh boreholes and plant recovery were recorded monthly.

Quantitative data were analyzed using descriptive statistics. Qualitative data were transcribed, coded, and analyzed thematically.

3. Results and Analysis

3.1 Quantitative Analysis of Farmer Perceptions

The calculated Farmer Acceptance Index (FAI) and parameter-wise mean scores are presented in Table 2.

Table 2: Farmer perception scores and Acceptance Index for evaluated practices.

Practice	Perceived Effectiveness	Economic Viability	Operational Simplicity	Overall Satisfaction	Farmer Acceptance Index (FAI)*
Crown Drenching (CD)	4.6	4.1	4.3	4.7	0.89
Beetle Traps (Trap)	3.5	3.0	2.8	3.6	0.62
3G Granules (Granule)	2.4	3.8	4.2	2.2	0.41
*FAI = (Sum of Normalized Scores for 4 Parameters) / 4; Range 0-1.					

Analysis: Crown drenching scored consistently high across all parameters, securing the highest FAI (0.89). A one-way ANOVA confirmed significant differences in Overall Satisfaction scores between the three practices ($F(2, 378) = 215.4, p < 0.001$). Post-hoc Tukey tests revealed that satisfaction with CD was significantly higher than with Traps ($p < 0.001$) and Granules ($p < 0.001$). The high score for Granules on Economic Viability, despite low effectiveness, warranted qualitative investigation.

3.2 Thematic Analysis of Qualitative Insights

FGDs provided depth to the numerical scores, revealing key themes

- **Theme 1: The Primacy of Immediate, Visual Results:** Farmers expressed strong preference for CD because results were "visible within a week." This immediacy trumped longer-term, preventive strategies.
- **Theme 2: Labour as a Critical Adoption Barrier:** The maintenance of traps emerged as a major deterrent. The "transaction cost" of daily labour significantly reduced its appeal.
- **Theme 3: Adaptive Use and Multi-Utility Valuation:** Over 85% of farmers praised 3G granules for an unintended benefit: "It definitely keeps rats and bandicoots away from chewing the stem." This repurposing highlights farmer innovation.
- **Theme 4: Trust in Direct Chemical Action:** CD was seen as "surgery" precise and potent. This trust was built on observable cause-and-effect, crucial for risk-averse farmers in a new crop system.

3.3 Field Validation and Correlation Analysis

Researcher data corroborated farmer perceptions. A significant negative correlation (Pearson's $r = -0.82, p < 0.01$) was found between the use of CD and the incidence of new crown damage symptoms across monitored plots. Trap efficacy was variable and highly dependent on maintenance frequency. No significant correlation was found between granule application and reduction in beetle damage, validating its poor rating for primary pest control.

4. Discussion

This study elucidates that in the dynamic context of Telangana's oil palm expansion, the adoption of pest management technology is a socio-technical process. The

superior acceptance of crown drenching aligns with the Technology Acceptance Model (TAM), where perceived usefulness (high efficacy) and perceived ease of use (direct application) drive adoption (Davis, 1989) [3]. Its success challenges the blanket advocacy of purely preventive controls in early-stage infestations where farmers require a "quick fix" (Van den Berg & Jiggins, 2007) [12].

The lukewarm reception to beetle traps underscores a classic extension dilemma. While agronomically sound, its adoption is hampered by high "perceived behavioural control" barriers primarily ongoing labour requirements (Ajzen, 1991) [1]. This suggests that trap-based management may be more viable as a community-managed, area-wide strategy rather than an individual responsibility.

The most insightful finding revolves around the revaluation of 3G granules. Farmers, as pragmatic problem-solvers, integrated this input into their local pest complex. This demonstrates farmer agency and innovation and cautions against a monolithic view of pesticide use (Stone, 2022) [11]. Extension messages could ethically leverage this by framing granule application as part of a "stem protection package" while being transparent about its limited efficacy against *O. rhinoceros*.

5. Conclusion and Recommendations

The rhinoceros beetle threatens the economic promise of oil palm in Telangana. This farmer-centric evaluation reveals that sustainable management will not be achieved by transferring packaged solutions, but by co-developing strategies that resonate with local realities.

Recommendations for a Hierarchical, Farmer-Centric IPM Protocol

1. **Immediate Curative Action:** Promote crown drenching with lambda-cyhalothrin as the primary responsive measure for visible infestation.
2. **Preventive & Community Strategy:** Position beetle traps as a collective tool for Farmer Producer Organizations (FPOs) to manage on a block scale.
3. **Honest Communication and Integration:** Advise on 3G granules explicitly for rodent management if needed, clearly distinguishing this from beetle control. Integrate mandatory field sanitation.
4. **Extension Approach:** Shift from prescriptive messaging to participatory demonstration using decision trees based on damage severity.

By anchoring pest management strategies in the lived experience of farmers, extension services can foster higher compliance and secure the sustainability of Telangana's oil palm frontier.

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