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Effectiveness of extension interventions in enhancing adoption of coconut tonic and nutrient management practices among coconut farmers of Ramanathapuram district, Tamil Nadu

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Abstract

Coconut cultivation in coastal and rainfed regions of Tamil Nadu is increasingly constrained by soil salinity, ageing plantations, nutrient deficiencies, and climate-induced pest incidence. Extension interventions play a critical role in promoting cost-effective technologies to enhance productivity under such vulnerable conditions. The present study assessed the effectiveness of extension interventions implemented by Krishi Vigyan Kendra (KVK), Ramanathapuram, in enhancing adoption of TNAU coconut tonic and recommended nutrient management practices among coconut farmers. An ex-post facto research design was adopted, and data were collected during 2023-2024 from 150 coconut farmers comprising beneficiaries and non-beneficiaries of frontline demonstrations and collective-based interventions. Results revealed significantly higher adoption of coconut tonic among beneficiary farmers (mean adoption score 1.52) compared to non-beneficiaries (0.80). Beneficiaries recorded higher nut yield (92 nuts palm⁻¹ year⁻¹) and net returns (₹1,970 palm⁻¹ year⁻¹) despite marginally higher cultivation costs. Extension contact, innovativeness, education, and risk orientation significantly influenced adoption behaviour, with extension contact emerging as the strongest predictor ($\beta = 0.42$). High input cost perception and price fluctuation were the major constraints limiting adoption. The study confirms that demonstration-based and collective extension approaches are effective in enhancing adoption of nutrient management technologies in coconut under rainfed and saline conditions.

Keywords: Adoption behaviour, coconut tonic, extension effectiveness, nutrient management, rainfed coconut

Introduction

Coconut (*Cocos nucifera* L.) is a perennial plantation crop of considerable economic importance in India, providing livelihood security to millions of small and marginal farmers. In Tamil Nadu, coconut cultivation is predominantly concentrated in coastal and semi-arid regions, where productivity is often constrained by erratic rainfall, soil salinity, poor soil fertility, and ageing plantations. Ramanathapuram district represents one of the most climate-vulnerable coconut-growing regions, characterized by low annual rainfall, coastal salinity intrusion, and limited irrigation infrastructure. Soil salinity and nutrient imbalance significantly reduce nutrient use efficiency in coconut, particularly micronutrients, thereby affecting palm vigour and nut yield (Nampoothiri *et al.* 2018) [2]. In addition, a large proportion of coconut palms in the region are 35-40 years old, further contributing to declining productivity. Climate variability has also intensified the incidence of sucking pests and diseases, increasing management costs and production risk. Under such conditions, farmers often perceive recommended fertilizer doses as uneconomical due to fluctuating coconut prices and delayed economic returns. Research institutions have developed nutrient supplements such as TNAU coconut tonic and advocated integrated nutrient management practices, including green manuring and intercropping, to improve nutrient availability and palm productivity. However, the effectiveness of these technologies depends largely on farmers' awareness, perception, and adoption behaviour. Extension interventions such as Frontline Demonstrations (FLDs) and collective-based approaches are critical in reducing knowledge gaps, demonstrating economic benefits, and facilitating adoption under field conditions.

Previous studies have reported positive impacts of FLDs on productivity and technology dissemination in plantation and field crops (Samui *et al.* 2000; Meena *et al.* 2016) ^[5, 1]. Nevertheless, adoption of nutrient management technologies in coconut remains uneven, particularly in resource-constrained and climate-risk-prone regions. Empirical studies assessing the effectiveness of extension interventions in improving adoption and productivity of coconut under rainfed and saline ecosystems are limited. Hence, the present study was undertaken to evaluate the effectiveness of extension interventions implemented by KVK Ramanathapuram in enhancing adoption of coconut tonic and nutrient management practices among coconut farmers.

Major objectives

1. To assess the effectiveness of extension interventions in improving the adoption of TNAU coconut tonic and recommended nutrient management practices among coconut farmers.
2. To evaluate the impact of FLDs and collective-based interventions on productivity and economic returns of coconut under coastal and rainfed conditions.
3. To analyse the socio-economic, institutional, and technological factors influencing adoption of coconut tonic and nutrient management practices.

Materials and Methods

Study Area

The study was conducted in Ramanathapuram district of Tamil Nadu, focusing on the major coconut-growing coastal blocks namely Thirupullani, Mandapam, and Thiruvadanai, covering approximately 8,500 ha under coconut. The district is characterized by rainfed coconut cultivation, saline soils, ageing plantations, and high climatic vulnerability, making it appropriate for assessing extension-led interventions in coconut productivity enhancement.

Research design

An ex-post facto research design was adopted, as the extension interventions had already been implemented through Frontline Demonstrations (FLDs) and NABARD-funded collective-based initiatives. The design facilitated assessment of adoption behaviour and impact under real farming conditions.

Extension interventions evaluated

The study evaluated the following interventions promoted by KVK Ramanathapuram:

1. Demonstration of TNAU coconut tonic
2. Demonstration of cowpea variety VBN 4 as an intercrop under coconut
3. NABARD-funded programme on “Compendium of Technologies for Productivity Improvement in Coconut Farming” implemented through farmer collectives

Sampling procedure and sample size

Three blocks were purposively selected based on coconut area and intervention coverage. From each block, villages where FLDs and collective-based activities were implemented were selected.

A total of 150 coconut farmers constituted the sample:

- 75 beneficiary farmers (exposed to FLDs / collective interventions)
- 75 non-beneficiary farmers (not exposed)

Non-beneficiaries were selected from the same villages to

control for agro-climatic variation.

Data collection

Primary data were collected using a pre-tested structured interview schedule through personal interviews. Secondary data from FLD records were used to assess productivity and economics.

Measurement of variables

Adoption behaviour

Adoption was measured using a three-point continuum: Fully adopted (2), Partially adopted (1), Not adopted (0). An Adoption Index was computed and respondents were categorized into low, medium, and high adoption groups.

Statistical analysis

- Descriptive statistics (mean, percentage)
- Correlation and multiple regression analysis
- Comparative analysis (beneficiary vs non-beneficiary)
- Garrett ranking technique for constraints

Results and Discussion

Effectiveness of Extension Interventions on Adoption of Coconut Tonic and Nutrient Management

Table 1 presents the adoption status of TNAU coconut tonic among beneficiary and non-beneficiary coconut farmers. A substantially higher proportion of beneficiary farmers (64.0%) fully adopted the coconut tonic compared to non-beneficiaries (22.7%). The marked difference in mean adoption scores (1.52 for beneficiaries and 0.80 for non-beneficiaries) clearly demonstrates the effectiveness of frontline demonstrations in promoting technology adoption.

Table 1: Adoption of TNAU coconut tonic among coconut farmers (n = 150)

Category	Beneficiaries (%)	Non-beneficiaries (%)
Fully adopted	64.0	22.7
Partially adopted	24.0	34.7
Not adopted	12.0	42.6
Mean adoption score	1.52	0.80

Frontline demonstrations facilitate experiential learning by enabling farmers to observe the performance of technologies under their own agro-ecological conditions, thereby reducing uncertainty and perceived risk (Samui *et al.* 2000; Meena *et al.* 2016) ^[5, 1]. In perennial crops such as coconut, where adoption decisions involve long-term implications, visual evidence of improvements in palm vigour and nut setting plays a critical role in influencing farmers' decisions (Rogers, 2003) ^[4]. Partial adoption observed among non-beneficiaries suggests that while awareness of coconut tonic exists, inadequate technical clarity regarding dosage, timing, and economic benefits constrains full adoption. Similar findings have been reported in studies on nutrient management technologies, where lack of hands-on exposure limited farmers' confidence to adopt recommended practices (Singh *et al.* 2017) ^[6].

Impact of extension interventions on coconut productivity and economics

The productivity and economic performance of beneficiary and non-beneficiary farmers are presented in Table 2. Beneficiary farmers recorded an average yield of 92 nuts palm⁻¹ year⁻¹, representing a 35.3 percent increase over non-beneficiaries (68 nuts palm⁻¹ year⁻¹). The yield advantage can be attributed to improved nutrient availability through

coconut tonic application and complementary benefits from cowpea intercropping, which enhances soil organic carbon and biological nitrogen fixation (Nampoothiri *et al.* 2018) [2].

Table 2: Impact of coconut tonic and nutrient management on yield and returns

Particulars	Beneficiaries	Non-beneficiaries
Nut yield (nuts/palm/year)	92	68
Yield increase (%)	35.3	-
Cost of cultivation (₹/palm/year)	1,250	1,080
Gross return (₹/palm/year)	3,220	2,380
Net return (₹/palm/year)	1,970	1,300
B:C ratio	2.58	2.20

Despite a marginal increase in cost of cultivation among beneficiaries, the substantial rise in gross and net returns resulted in a higher benefit-cost ratio (2.58) compared to non-beneficiaries (2.20). This finding corroborates earlier studies that reported higher profitability of coconut-based integrated nutrient management practices when supported by effective extension interventions (Patil *et al.* 2019) [3].

The economic gains observed among beneficiary farmers are particularly significant in the context of Ramanathapuram district, where farmers often perceive fertilizer application as uneconomical due to fluctuating coconut prices. Demonstration-based evidence of profitability plays a decisive role in altering farmers' cost-benefit perception, a key determinant of adoption behaviour (Rogers, 2003) [4].

Factors influencing adoption of coconut tonic and nutrient management practices

Correlation analysis (Table 3) revealed that education, extension contact, innovativeness, and risk orientation were positively and significantly associated with adoption of coconut tonic and nutrient management practices. Extension contact exhibited the strongest correlation ($r = 0.58$), indicating that frequent interaction with extension personnel significantly enhanced farmers' knowledge and confidence. The positive association between innovativeness and adoption ($r = 0.49$) aligns with diffusion theory, which emphasizes that innovative farmers are more willing to experiment with new technologies and act as early adopters within rural communities (Rogers, 2003) [4]. Risk orientation also showed a strong relationship with adoption ($r = 0.46$), reflecting farmers' capacity to manage uncertainty under rainfed and climate-stressed conditions. Similar relationships between psychological traits and adoption have been reported in earlier extension studies (Meena *et al.* 2016; Singh *et al.* 2017) [1, 6]. The relatively weaker yet significant association with farm size suggests that adoption was not exclusively resource-driven, highlighting the inclusiveness of KVK-led extension interventions.

Determinants of adoption

Multiple regression analysis (Table 4) explained 65 percent of the variation in adoption behaviour ($R^2 = 0.65$), indicating that the selected variables adequately captured the major determinants of adoption. Extension contact emerged as the most influential predictor ($\beta = 0.42$), reinforcing the pivotal role of institutional extension support in facilitating adoption of nutrient management technologies.

The significance of innovativeness ($\beta = 0.28$) and risk orientation ($\beta = 0.24$) confirms that behavioural attributes substantially influence adoption decisions, particularly in

perennial cropping systems where farmers weigh long-term benefits against short-term costs (Rogers, 2003) [4]. Education ($\beta = 0.21$) contributed by enhancing farmers' ability to comprehend scientific recommendations and nutrient deficiency symptoms, as reported in earlier studies on adoption of improved agricultural practices (Samui *et al.* 2000) [2].

The findings emphasize that strengthening extension contact and nurturing farmer innovativeness through continuous capacity building are critical for accelerating adoption in climate-vulnerable regions.

Table 3: Correlation between selected variables and adoption behaviour

Variable	Correlation coefficient (r)
Education	0.41**
Extension contact	0.58**
Innovativeness	0.49**
Risk orientation	0.46**
Farm size	0.22*

Table 4: Multiple regression analysis of factors influencing adoption ($R^2 = 0.65$)

Variable	β value	Significance
Extension contact	0.42	**
Innovativeness	0.28	**
Education	0.21	*
Risk orientation	0.24	**

Constraints in adoption of improved coconut management practices

Constraint analysis (Table 5) revealed that perceived high cost of inputs was the most severe constraint (Garrett score 71.6), followed by low and fluctuating coconut prices (66.2). These results indicate that economic factors outweigh technical constraints in influencing adoption decisions, a trend commonly observed in plantation crops (Patil *et al.* 2019) [3].

Soil salinity-induced nutrient stress and ageing coconut palms were identified as major biophysical constraints, corroborating earlier reports on declining nutrient use efficiency and productivity in coastal coconut-growing regions (Nampoothiri *et al.* 2018) [2]. Increasing pest and disease incidence, attributed to changing climatic conditions, further complicates adoption by increasing management costs and production risk.

The constraint pattern underscores the need for integrated extension strategies combining nutrient management with plantation rejuvenation, collective input procurement, and market-linked interventions to sustain adoption in the long term.

Table 5: Constraints faced by coconut farmers in adoption of improved practices

Rank	Constraint	Garrett score
1	High-cost perception of inputs	71.6
2	Low and fluctuating coconut prices	66.2
3	Salinity-induced nutrient stress	61.4
4	Old and senile palms	58.7
5	Pest and disease incidence	54.9

Conclusion and policy implications

The present study unequivocally demonstrates that well-designed extension interventions, particularly frontline demonstrations and collective-based approaches, are highly effective in enhancing adoption of TNAU coconut tonic and recommended nutrient management practices among coconut farmers in the climate-vulnerable coastal ecosystem

of Ramanathapuram district. The significant improvement in adoption behaviour among beneficiary farmers translated into measurable gains in coconut productivity and farm income, despite the inherent constraints of rainfed cultivation, soil salinity, ageing plantations, and climatic variability.

The findings highlight that extension contact emerged as the most critical determinant of adoption, underscoring the pivotal role of Krishi Vigyan Kendras in bridging the gap between technology generation and field-level application. Demonstration-based extension enabled farmers to overcome risk perception and economic apprehension associated with nutrient inputs by providing visible and locally validated evidence of benefits. The results also emphasize that behavioural attributes such as innovativeness and risk orientation significantly shape adoption decisions, particularly in perennial crops where investment returns are realized over longer time horizons.

Policy implications

From a policy perspective, the study underscores the need to institutionalize demonstration-led extension approaches in coconut development programmes, especially in rainfed and saline-prone regions. Input subsidy and support schemes should be complemented with on-field demonstrations and follow-up advisory services, rather than stand-alone distribution of inputs. Strengthening farmer collectives and producer groups can further enhance adoption by facilitating collective input procurement, reducing cost burdens, and improving market access, thereby addressing the economic constraints identified in the study.

The results also suggest that nutrient management interventions should be integrated with plantation rejuvenation programmes for ageing coconut palms. Policymakers may consider promoting bundled technology packages that combine coconut tonic application, green manuring, intercropping, and soil health improvement measures, supported through convergence of ICAR, Coconut Development Board, and NABARD initiatives.

Future thrust areas for KVK research and extension

Based on the empirical evidence generated, the following thrust areas merit priority attention in future KVK research and extension programmes:

1. **Long-term impact assessment:** Conduct longitudinal studies to assess sustained impact of coconut tonic and nutrient management practices on productivity, soil health, and resilience under climate variability.
2. **Cost optimization research:** Develop and validate low-cost, locally available nutrient formulations and integrated nutrient management strategies to improve affordability for small and marginal coconut farmers.
3. **Plantation rejuvenation technologies:** Focus research on integrated rejuvenation packages for senile coconut palms, combining nutrient management, canopy management, and pest-disease control.
4. **Climate-smart coconut systems:** Strengthen research on climate-resilient coconut-based cropping systems, including drought-tolerant intercrops, moisture conservation practices, and salinity management techniques.
5. **Digital and advisory innovations:** Explore the role of digital extension tools, mobile advisories, and decision-support systems in improving timely nutrient application and pest management in coconut.
6. **Collective-based extension models:** Evaluate the effectiveness of farmer collectives, FPOs, and SHG-

based extension approaches in enhancing adoption, reducing input costs, and improving market realization.

Conclusion

The study reinforces the central role of KVKs as catalysts of technology adoption and livelihood enhancement in vulnerable agro-ecosystems. A strategic blend of demonstration-led extension, collective action, and policy convergence is essential for achieving sustainable productivity improvement in coconut cultivation in coastal districts such as Ramanathapuram.

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