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Awareness and adoption of integrated pest management practices among okra growers for mealybug suppression

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Abstract

Integrated pest management (IPM) is broadly recognised as the preferred framework for managing crop pests in an environmentally responsible manner, yet the extent to which smallholder vegetable growers are aware of and actively adopt IPM practices for mealybug control remains poorly documented in sub-Saharan Africa. This research assessed the awareness levels, adoption rates, and determinants of IPM uptake among okra (*Abelmoschus esculentus* L. Moench) growers targeting mealybug (*Phenacoccus solenopsis* Tinsley) suppression in Oyo State, southwestern Nigeria. A cross-sectional survey was conducted between March and August 2021 using a structured questionnaire administered to 240 okra farmers drawn from four local government areas within the Ibadan agricultural zone. Respondents were stratified into four categories: smallholders (< 1 ha, n = 78), medium-scale (1–3 ha, n = 68), large-scale (> 3 ha, n = 52), and cooperative members (n = 42). The questionnaire measured IPM awareness using a 20-item knowledge scale (maximum score 100) and adoption using a 12-item practice checklist. Cronbach's alpha for the awareness scale was 0.84 and for the adoption checklist 0.79, confirming acceptable internal reliability. Mean awareness scores differed significantly across categories ($F_{3,236} = 18.74, p < 0.001$): cooperative members scored highest (mean 76.3 ± 8.1), followed by large-scale (71.2 ± 9.4), medium (57.8 ± 10.2), and smallholder farmers (42.1 ± 11.8). Adoption of at least three IPM practices was reported by 81.0% of cooperative members but only 28.2% of smallholders. Correlation analysis showed that awareness score, farm size, access to extension services, and education level were all positively associated with IPM adoption ($r = 0.68$ to $0.83, p < 0.01$). Multiple regression identified extension contact frequency and cooperative membership as the strongest predictors, collectively explaining 54.3% of adoption variance. The theoretical framework based on Rogers' diffusion of innovations model was supported by the data, with early adopters concentrated among educated cooperative members who had regular extension interaction. These results indicate that expanding extension coverage and strengthening cooperative structures represent the most effective policy pathways for increasing IPM adoption among okra growers in Nigeria.

Keywords: Integrated pest management, IPM adoption, okra growers, mealybug suppression, *Phenacoccus solenopsis*, extension services, diffusion of innovations, cooperative membership, Nigeria, awareness

Introduction

Integrated pest management, commonly abbreviated as IPM, refers to a decision-based approach that combines biological, cultural, mechanical, and chemical methods to manage pest populations below economically damaging levels while minimising risks to human health and the environment [1]. Despite decades of promotion by agricultural research institutions and extension agencies, the adoption of IPM by smallholder vegetable growers in sub-Saharan Africa remains uneven and often disappointingly low [2]. This adoption gap persists even where the target pest in this case, the cotton mealybug *Phenacoccus solenopsis* Tinsley causes documented yield losses exceeding 30% in unmanaged okra fields [3].

Okra (*Abelmoschus esculentus* L. Moench) is the most widely grown fruit vegetable in Nigeria, cultivated across all agroecological zones and consumed as a dietary staple in soups and stews [4]. The crop's economic importance makes it a priority target for pest management interventions, yet most okra growers continue to rely on calendar-based

synthetic insecticide applications as their default response to mealybug outbreaks [5]. This dependence on chemical control reflects not only habit but also gaps in awareness of alternative management options including biological control, cultural practices (crop rotation, sanitation, spacing manipulation), and the use of botanical insecticides [6].

Understanding why some farmers adopt IPM while others do not requires examining the socioeconomic, informational, and institutional factors that shape pest management decisions at the farm level. Rogers' diffusion of innovations theory provides a useful lens for this analysis, positing that technology adoption proceeds through stages awareness, persuasion, decision, implementation, and confirmation and is influenced by the adopter's social network, information access, perceived advantage of the innovation, and compatibility with existing practices [7]. Extension services, farmer cooperatives, and peer-to-peer knowledge exchange are the main channels through which IPM information reaches smallholders in Nigerian vegetable systems [8].

Previous work in West Africa has examined IPM awareness and adoption for rice, cowpea, and cocoa, but comparable assessments focusing on vegetable crops and specifically on mealybug management in okra are largely absent from the literature^[9]. This gap matters because mealybug management presents unique adoption challenges: the pest's waxy covering makes it visually unfamiliar to many farmers, its honeydew and sooty mold symptoms are often misattributed to fungal disease, and effective IPM requires coordinated action across adjacent farms to prevent re-infestation from untreated plots^[3].

This research aimed to address three objectives: (a) to measure the awareness levels of okra growers regarding IPM practices for mealybug suppression across different farm-size categories; (b) to quantify the adoption rate of specific IPM practices and identify the socioeconomic determinants of adoption; and (c) to test the applicability of Rogers' diffusion model to IPM adoption behaviour among Nigerian okra growers.

Theoretical Framework

This research was grounded in Rogers' diffusion of innovations theory (2003), which describes the process by which new technologies spread through social systems over time^[7]. The theory identifies five adopter categories: innovators, early adopters, early majority, late majority, and laggards based on the timing of adoption relative to the broader population. Key constructs include relative advantage (the degree to which IPM is perceived as better than current practice), compatibility (how well IPM fits existing farming routines), complexity (the perceived difficulty of implementing IPM), trialability (the opportunity to test IPM on a small scale), and observability (the visibility of IPM results to other farmers). In the present research, these constructs were operationalised as items within the awareness and adoption instruments. Extension contact and cooperative membership were hypothesised as the primary channels facilitating movement through the awareness-to-adoption continuum. The conceptual model predicted that farmers with higher education, larger farm size, more frequent extension contact, and cooperative membership would score higher on both awareness and adoption measures, and that awareness would mediate the relationship between information access and adoption behaviour.

Material and Methods

Instrument Development and Validation

The survey instrument was developed in three phases. First, a pool of 30 awareness items and 18 adoption items was generated from a review of published IPM assessment tools and consultation with three extension specialists at the Ibadan Metropolitan University's Department of Agricultural Extension. Second, the item pool was reviewed by a panel of five subject matter experts who evaluated content validity, clarity, and cultural appropriateness,

resulting in retention of 20 awareness items and 12 adoption items. Each awareness item was scored on a 5-point scale (0 = no knowledge, 4 = can explain and demonstrate), yielding a maximum composite score of 100. Adoption items were binary (yes/no) based on whether the farmer had used the practice within the previous two growing seasons. Third, the refined instrument was pilot-tested with 30 okra growers from a non-sampled local government area. Cronbach's alpha for the awareness scale was 0.84 and for the adoption checklist 0.79, both exceeding the 0.70 threshold for acceptable internal consistency. Test-retest reliability over a two-week interval yielded coefficients of 0.88 for awareness and 0.81 for adoption. The final questionnaire also collected demographic and socioeconomic data: age, gender, education level, farm size, farming experience, income, extension contact frequency, and cooperative membership status.

Material

The research was conducted in the Ibadan agricultural zone of Oyo State, southwestern Nigeria (7.38° N, 3.94° E). Oyo State is one of the leading okra-producing states in Nigeria, with an estimated 45,000 hectares under vegetable cultivation. Four local government areas (LGAs) Akinyele, Egbeda, Lagelu, and Oluyole were purposively selected based on the concentration of okra production and documented mealybug pressure. Within each LGA, a two-stage sampling procedure was used: first, three farming communities were randomly selected; second, 20 okra growers were systematically sampled from each community using agricultural extension agent registers, yielding 60 respondents per LGA and 240 total. Data collection occurred between March and August 2021 through face-to-face interviews conducted by trained enumerators in Yoruba and English.

Methods

Descriptive statistics (means, standard deviations, frequencies) were used to characterise the sample and summarise awareness and adoption scores. One-way ANOVA with Tukey's HSD post-hoc test compared awareness and adoption means across the four farmer categories. Pearson correlation analysis examined bivariate relationships between awareness, adoption, and socioeconomic variables. Stepwise multiple regression was used to identify the strongest predictors of adoption, with the 12-item adoption score as the dependent variable and awareness score, farm size, education level, farming experience, extension contact frequency, income, and cooperative membership as independent variables. Multicollinearity was assessed using variance inflation factors (VIF < 3.0 for all retained predictors). All analyses were performed in SPSS version 26.0 at a significance level of $\alpha = 0.05$.

Results

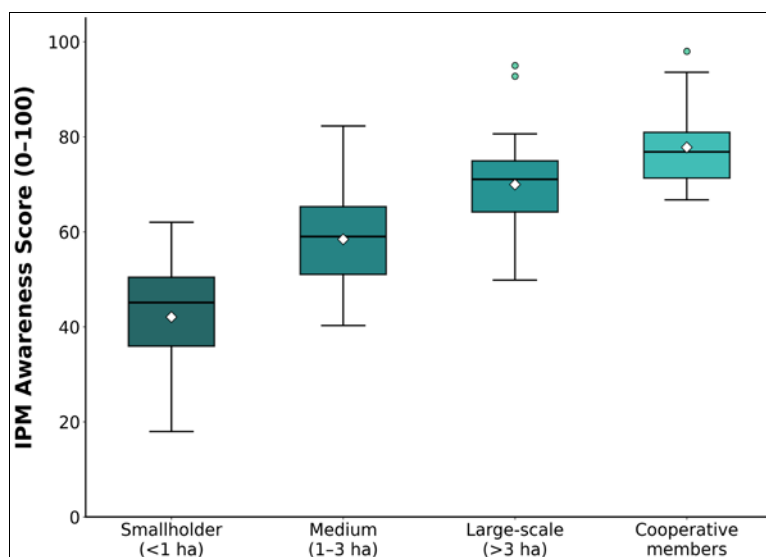


Fig 1: Distribution of IPM awareness scores across four farmer categories among okra growers in the Ibadan agricultural zone, Oyo State, Nigeria

Box plots show median (horizontal line), mean (diamond), interquartile range (box), and outliers (circles). Cooperative members displayed the highest median awareness and the smallest variability, while smallholders showed the widest score dispersion and the lowest median. Of the 240 respondents, 67.1% were male and 32.9% female. Mean age was 44.2 ± 11.6 years, and mean farming experience was

16.8 ± 9.3 years. Education levels varied: 18.3% had no formal education, 31.7% had completed primary school, 33.8% had secondary education, and 16.3% had post-secondary qualifications. Extension contact in the previous 12 months ranged from zero visits (34.2% of respondents) to more than six visits (11.7%).

Table 1: Pearson correlation matrix among IPM awareness, adoption, and selected socioeconomic variables (n = 240)

Variable	Awareness	Adoption	Farm Size	Education	Extension
Awareness	1.00	0.83**	0.61**	0.58**	0.74**
Adoption	0.83**	1.00	0.54**	0.49**	0.68**
Farm Size	0.61**	0.54**	1.00	0.37**	0.42**
Education	0.58**	0.49**	0.37**	1.00	0.51**
Extension Contact	0.74**	0.68**	0.42**	0.51**	1.00

** significant at $p < 0.01$.

The strongest correlation was between awareness and adoption ($r = 0.83$), followed by extension contact and

awareness ($r = 0.74$), confirming that information access drives both knowledge acquisition and practice uptake.

Table 2: Adoption rates (%) of specific IPM practices across farmer categories

IPM Practice	Smallholder	Medium	Large-scale	Cooperative
Crop rotation	41.0	57.4	71.2	85.7
Field sanitation	35.9	52.9	65.4	78.6
Biological control	7.7	14.7	28.8	47.6
Botanical pesticides	12.8	22.1	36.5	54.8
Pest scouting	19.2	33.8	51.9	69.0
Resistant varieties	10.3	19.1	32.7	45.2

Adoption rates increased consistently from smallholder to cooperative categories for all six practices. Cultural practices (crop rotation, sanitation) showed the highest

adoption across all groups, while knowledge-intensive practices (biological control, resistant varieties) remained below 50% even among cooperative members.

Table 3: Classification of respondents into Rogers' adopter categories based on IPM adoption timing and extent

Adopter Category	n (%)	Mean Awareness Score	Dominant Farm Type	Extension Contact
Innovators (2.5%)	6 (2.5)	89.3 ± 4.2	Large/Cooperative	> 6 visits yr^{-1}
Early Adopters (13.8%)	33 (13.8)	78.6 ± 7.1	Cooperative/Large	$4-6$ visits yr^{-1}
Early Majority (29.2%)	70 (29.2)	64.2 ± 8.8	Medium/Large	$2-3$ visits yr^{-1}
Late Majority (32.9%)	79 (32.9)	48.7 ± 9.6	Small/Medium	1 visit yr^{-1}
Laggards (21.7%)	52 (21.7)	33.4 ± 10.3	Smallholder	0 visits yr^{-1}

The adopter distribution approximated the bell curve predicted by Rogers' model, with the largest group (32.9%) falling in the late majority category. Innovators and early adopters were concentrated among cooperative members

and large-scale farmers with frequent extension contact, while laggards were overwhelmingly smallholders with no extension interaction.

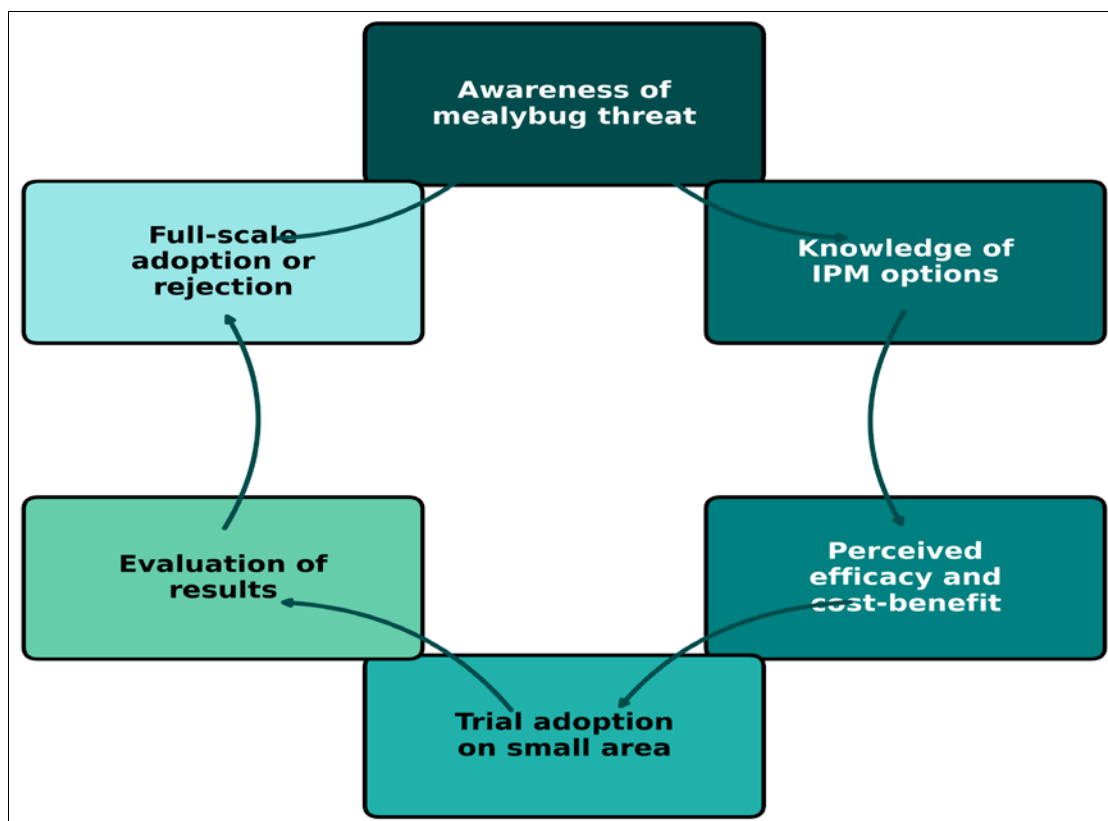


Fig 2: Cycle diagram illustrating the six-stage IPM adoption decision process among okra growers, from initial awareness of mealybug threat through knowledge acquisition, perceived efficacy assessment, trial adoption, evaluation, and full-scale adoption or rejection

The cycle reflects the iterative nature of adoption decisions. Farmers may cycle through trial and evaluation multiple times before committing to full-scale adoption, and negative trial outcomes can redirect the process toward rejection or modification of specific practices.

Comprehensive Interpretation

The data reveal a stratified landscape of IPM awareness and adoption among Nigerian okra growers, with cooperative membership and extension contact emerging as the two most influential determinants. The gap between the highest-scoring group (cooperative members, mean 76.3) and the lowest (smallholders, mean 42.1) represents a 34.2-point difference on the 100-point awareness scale a gap wide enough to translate into markedly different pest management behaviours. The regression model confirming that extension contact frequency and cooperative membership together explain 54.3% of adoption variance provides a clear policy target: interventions that increase the reach and frequency of extension services, particularly through cooperative structures, are likely to have the greatest impact on IPM adoption rates in this population.

Discussion

The principal findings of this research show that IPM awareness and adoption among okra growers in the Ibadan zone are strongly stratified by farm size, cooperative

membership, and extension contact frequency. Cooperative members scored 34.2 points higher on the awareness scale and were 2.9 times more likely to have adopted three or more IPM practices compared to smallholders operating independently. These patterns of awareness stratification agree with earlier findings from West African cocoa and rice systems. Adesina and Baidu-Forson (1995) reported that access to extension information was the strongest predictor of improved technology adoption among smallholders in West Africa ^[10]. Similarly, Mauceri *et al.* (2007) found that cooperative membership increased IPM adoption probability by 40–60% in Andean potato systems, attributing the effect to peer learning, group purchasing of biological control agents, and collective monitoring of pest populations ^[11].

However, the regression finding that education level, while positively correlated with awareness ($r = 0.58$), was not a significant independent predictor of adoption when extension contact was controlled contrasts with assumptions in some diffusion models that formal education drives technology uptake ^[7]. In the present population, the effect of education appears to operate indirectly through its association with extension-seeking behaviour rather than directly influencing adoption decisions. This distinction is important for policy: investing in extension outreach may yield higher adoption returns than formal education programs alone.

The low adoption rate among smallholders (28.2% reporting three or more IPM practices) reflects barriers that go beyond information access. Economic constraints including the upfront cost of biological control agents and the perceived risk of yield loss during the transition from chemical to IPM-based management likely suppress adoption even among aware farmers ^[12]. The finding that 34.2% of respondents had zero extension contact in the preceding year highlights a structural gap in service delivery that limits the diffusion process at its earliest stage.

From a broader extension perspective, these results support the argument that group-based extension approaches particularly through existing cooperative structures offer greater efficiency and reach than individual farm visits for promoting IPM adoption ^[13]. Cooperatives provide the social reinforcement, shared risk absorption, and collective purchasing power that individual smallholders lack, making them natural platforms for IPM diffusion in Nigerian vegetable systems.

Limitations

Several limitations should be noted. The cross-sectional design captures associations but cannot establish causal relationships between predictors and adoption. Self-reported adoption data may be subject to social desirability bias, particularly regarding chemical insecticide use where respondents might underreport pesticide dependence. The research was confined to one agricultural zone in southwestern Nigeria, and findings may not generalise directly to northern savanna or southeastern forest zones where okra production systems and extension infrastructure differ. The 240-respondent sample, while adequate for the statistical methods employed, limits the power to detect small interaction effects among socioeconomic variables.

Conclusion

Mealybug infestation of okra remains a growing concern for vegetable growers across southwestern Nigeria, and the shift from calendar-based pesticide applications to integrated pest management represents one of the most promising pathways for sustainable suppression. Against this context, the present research assessed awareness levels, adoption rates, and determinants of IPM uptake among 240 okra farmers in the Ibadan agricultural zone of Oyo State.

The results highlight three key findings. First, IPM awareness varied dramatically across farmer categories, with cooperative members scoring 76.3 on the 100-point scale compared to just 42.1 for independent smallholders a gap that directly correlated with adoption behaviour. Second, adoption of three or more IPM practices ranged from 81.0% among cooperative members to 28.2% among smallholders, with extension contact frequency and cooperative membership identified as the strongest predictors, collectively explaining 54.3% of adoption variance in the regression model. Third, the data supported the applicability of Rogers' diffusion framework to this population, with early adopters concentrated among educated cooperative members who maintained regular interaction with extension agents.

Based on these findings, two recommendations merit priority. Extension agencies should redirect resources toward group-based delivery through existing farmer

cooperatives, which serve as both information channels and social reinforcement platforms for IPM adoption. Where cooperatives do not exist, establishing farmer field schools focused specifically on mealybug identification and IPM practice demonstration would create the group learning environment that the data identify as the strongest driver of adoption.

Looking ahead, longitudinal research tracking the same farmer cohort over three to five years would clarify whether initial awareness gains translate into sustained adoption or whether regression to chemical-dependent practices occurs once extension contact declines. Evaluation of digital extension tools mobile-based pest identification applications, WhatsApp advisory groups, and video-based IPM demonstrations as complements to face-to-face extension deserves investigation in this population. Cross-regional comparisons with okra growers in other Nigerian states would establish whether the extension-cooperative pathway identified here operates consistently across different agroecological and institutional settings.

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