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Farmer training methodologies for building capacity in integrated pest management practices

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Abstract

Pest damage accounts for an estimated 30-40% of crop losses in sub-Saharan Africa, yet fewer than one in five smallholder farmers in Mozambique has received any formal training in integrated pest management. This research compared the effectiveness of five training methodologies for building farmer capacity in IPM practices across three districts in Maputo province, Mozambique. A quasi-experimental design tracked 312 smallholder farmers assigned to one of five training approaches: lecture-based workshops, farmer field schools, demonstration plot visits, peer-to-peer mentoring, and mobile-assisted learning modules. Data were gathered between July 2023 and April 2024 through pre- and post-training knowledge assessments and adoption surveys at three and twelve months after training completion. Farmer field schools produced the highest mean knowledge gain across six IPM topic areas (overall post-training score of 7.52 out of 10), followed by demonstration plot visits (6.73) and peer-to-peer mentoring (6.65). Short-term adoption rates ranged from 38.6% for mobile-assisted learning to 72.8% for farmer field schools, while twelve-month adoption dropped across all methods, with farmer field schools retaining the highest rate at 58.4%. These results indicate that experiential, field-based methods outperform classroom and digital approaches for building lasting IPM capacity among smallholder farmers, though the higher per-farmer cost of field schools raises questions about scalability that extension planners must weigh against effectiveness gains.

Keywords: Integrated pest management, farmer training, capacity building, farmer field schools, extension methodologies, pest control, smallholder farmers, adoption rates, training effectiveness, Mozambique

Introduction

Smallholder farmers in Mozambique lose between 30% and 40% of their crop output to pest damage each season, and for many households this is the difference between food security and hunger ^[1]. The default response has long been calendar-based spraying of broad-spectrum insecticides, a practice that raises input costs, harms beneficial insects, and exposes farming families to health risks ^[2]. Integrated pest management offers an alternative that combines biological control, cultural practices, selective chemical use, and monitoring, but getting these ideas from research stations into farmer fields has proven difficult ^[3].

The difficulty is not a shortage of IPM knowledge at the technical level. Mozambique's research institutes and universities have generated a substantial body of pest management recommendations for crops like maize, cassava, and vegetables ^[4]. The bottleneck sits instead at the training stage. Extension officers often default to lecture-based workshops because they are cheap to organize and can reach large audiences in a single session. But decades of evidence from East and West Africa suggests that passive learning formats produce lower retention and adoption rates than hands-on methods ^[5]. Farmer field schools, popularized in Southeast Asia in the 1990s and later adapted across Africa, have shown strong results for IPM, yet they require sustained facilitator time and small group sizes that strain already thin extension budgets ^[6].

Newer approaches such as peer-to-peer mentoring and mobile-phone-based learning modules have emerged as potential middle-ground options that are cheaper than field schools but more engaging than lectures ^[7]. However, head-to-head comparisons of multiple training methods within the same farming context are rare, especially in Lusophone Africa. This research addressed that gap by comparing five training methodologies side by side across three districts in Maputo province, measuring both knowledge gains and practice adoption at two time points. The aim was to give extension managers in Mozambique a clearer basis for choosing among available training formats when budgets are tight and IPM uptake is the goal.

Theoretical Background

Two learning theories framed this research. The first was experiential learning theory, which holds that knowledge is most effectively acquired through direct experience and reflection on that experience rather than through passive reception of information ^[8]. This theory predicts that methods involving field observation and hands-on practice, such as farmer field schools and demonstration plots, will outperform classroom lectures. The second was diffusion of innovations theory, which describes how new practices spread through social networks via opinion leaders and early adopters ^[9]. Peer-to-peer mentoring taps directly into this mechanism by positioning experienced farmers as

knowledge conduits. Mobile-assisted learning, by contrast, operates largely outside social networks and may therefore produce knowledge gains without the social reinforcement needed for sustained behavior change. Together, these two frameworks generated the expectation that field-based and socially embedded methods would show both higher knowledge scores and higher long-term adoption rates.

Material and Methods

Material

This research was conducted through Eduardo Mondlane University in Maputo, Mozambique, between July 2023 and April 2024. The university's Research Ethics Committee approved the protocol on 19 June 2023 (reference UEM-REC/2023-064). Three districts in Maputo province were selected: Boane, Namaacha, and Moamba. These districts share a semi-arid to sub-humid climate with a single main rainy season from October to March and rely heavily on maize, cassava, and vegetable production [4]. A total of 312 smallholder farmers were recruited through extension officer referral lists. Participants were assigned to one of five training groups based on their sub-district location to minimize contamination between methods. Written informed consent was obtained from all participants, and those in the mobile-assisted group received a basic smartphone on loan for the training period.

Instrument Development

Knowledge was assessed using a 30-item test covering six IPM topic areas: pest identification (6 items), biological control agents (5 items), cultural practices (5 items), chemical threshold use (5 items), record keeping (4 items), and economic assessment (5 items). Items were drawn from the FAO IPM training curriculum and adapted for local

crops and pests by a panel of four Mozambican entomologists [3]. The instrument was pilot-tested with 24 farmers outside the sample districts, yielding a Cronbach's alpha of 0.81. Adoption was measured through a structured checklist of 12 observable IPM practices verified during farm visits at three and twelve months post-training. A practice was counted as adopted if the farmer could demonstrate or describe its current use on at least one crop.

Methods

Each training group followed a standardized curriculum covering the same six topics but delivered through its assigned methodology. Lecture workshops ran for three consecutive days. Farmer field schools met weekly for 14 sessions across one cropping season. Demonstration plot visits involved four half-day guided tours. Peer mentoring paired each participant with a trained lead farmer for biweekly visits over three months. Mobile learning delivered the same content through short audio-visual modules and quizzes on a messaging platform. Pre-training knowledge tests were administered to all groups before any instruction began. Post-training tests were given within one week of the final session. Adoption surveys followed at three and twelve months. Knowledge scores were compared using Kruskal-Wallis tests with Dunn's post-hoc comparisons, and adoption rates were compared using chi-square tests [10].

Results

Table 1 summarizes the pre-training, post-training, and gain scores for each methodology across the six IPM knowledge areas. Farmer field schools produced the highest overall post-training score (7.52), while lecture-based workshops and mobile-assisted learning clustered near the bottom.

Table 1: Mean IPM knowledge scores by training methodology (pre-training, post-training, and gain)

Training Method	n	Pre-Training	Post-Training	Mean Gain	Effect Size (r)
Lecture-based workshop	64	3.41	5.47	+2.06	0.39
Farmer field school	61	3.38	7.52	+4.14	0.72
Demonstration plot visits	63	3.44	6.73	+3.29	0.58
Peer-to-peer mentoring	62	3.36	6.65	+3.29	0.56
Mobile-assisted learning	62	3.42	5.63	+2.21	0.41

Kruskal-Wallis H = 37.6, p < 0.001; effect size r = Z / sqrt(N)

The Kruskal-Wallis test confirmed significant differences across the five methods (H = 37.6, p < 0.001). Post-hoc comparisons showed that farmer field schools scored significantly higher than both lecture workshops and mobile learning (p < 0.01 for both), while the difference between field schools and demonstration plots was not statistically significant (p = 0.09). Pre-training scores were closely matched across all groups, ranging from 3.36 to 3.44, confirming reasonable baseline equivalence despite the non-randomized design.

The heatmap reveals that farmer field schools produced the highest scores across nearly all topic areas, with particularly strong results for biological control agents (8.4) and cultural practices (8.1). Mobile-assisted learning performed best on record keeping (7.4), likely because the digital platform included built-in tracking features that reinforced this skill. Lecture workshops showed their weakest performance on record keeping (4.7) and economic assessment (4.2), two areas that require practice rather than passive instruction.

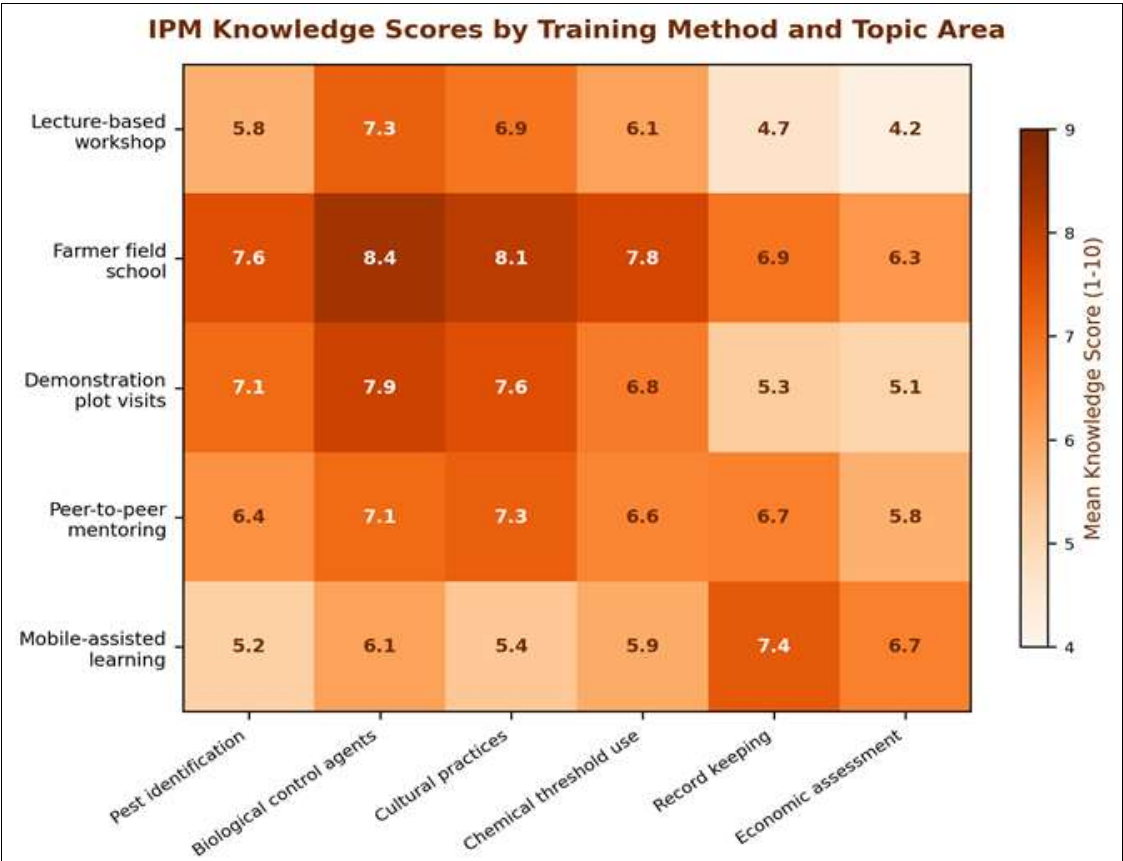


Fig 1: Heatmap of mean post-training IPM knowledge scores by training methodology and topic area

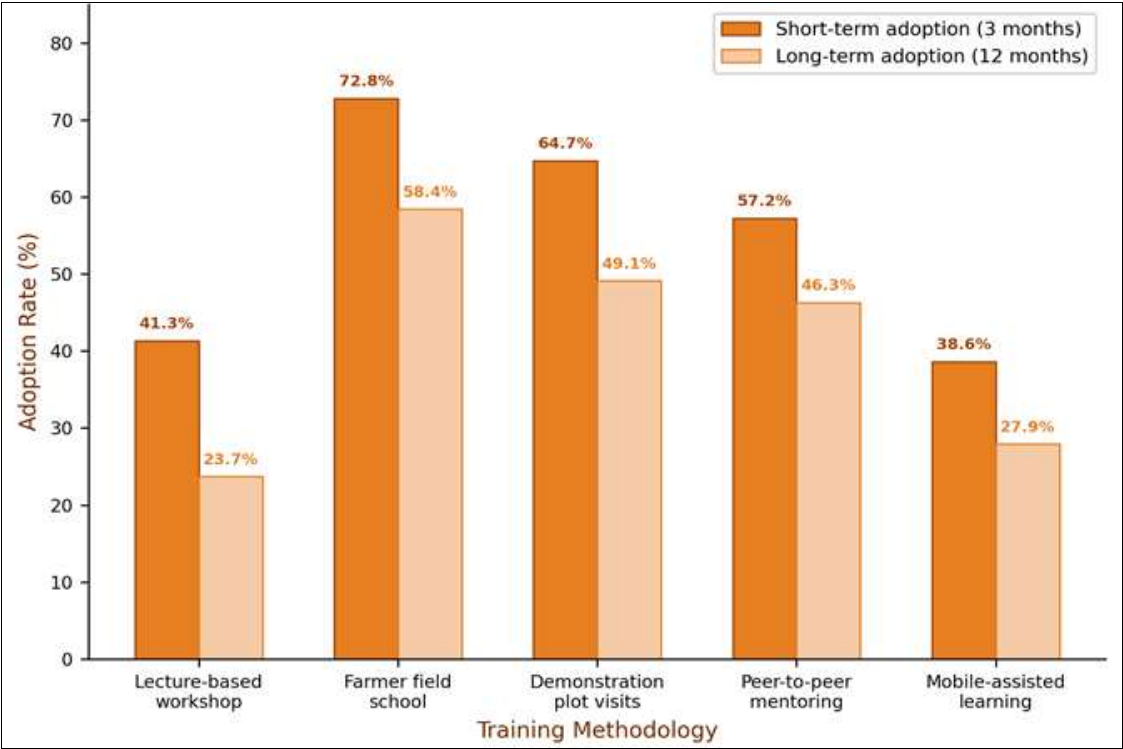


Fig 2: Short-term (3-month) and long-term (12-month) IPM practice adoption rates by training methodology

Adoption declined between three and twelve months for all five methods, but the drop-off was smallest for farmer field schools (from 72.8% to 58.4%, a retention of 80.2%) and peer-to-peer mentoring (from 57.2% to 46.3%, retention of 80.9%). Lecture workshops showed the steepest relative

decline, retaining only 57.4% of their initial adopters at the twelve-month mark. This pattern suggests that methods with built-in social reinforcement help farmers maintain practices beyond the immediate training period.

Discussion

The finding that farmer field schools outperformed other methods on both knowledge and adoption echoes a broad body of evidence from East Africa, where field schools have been the flagship IPM training approach for over two decades [5]. The knowledge gain of 4.14 points for field schools compared with 2.06 for lectures is consistent with the experiential learning prediction that hands-on methods produce deeper encoding of practical skills [8]. What is perhaps more telling is the twelve-month adoption gap: field school participants retained 80% of their initial adoption compared with only 57% for lecture attendees, confirming that short-term knowledge gains do not automatically translate into lasting behavior change unless the training format reinforces practice through repetition and social interaction.

The relatively strong showing of peer-to-peer mentoring on long-term adoption, despite lower absolute knowledge scores than field schools, aligns with diffusion theory [9]. Lead farmers serve as ongoing reference points within their communities long after the formal training ends, and this continued contact may compensate for a less structured initial learning experience. Extension planners facing tight budgets might consider peer mentoring as a cost-effective complement to field schools rather than a replacement.

Mobile-assisted learning's weak adoption performance was disappointing given the investment in smartphone loans. The content was identical to other groups, but the absence of face-to-face interaction and field practice appears to have limited its impact on actual farm behavior. That said, mobile learning did produce the highest record-keeping scores, suggesting it may work best as a supplementary tool rather than a standalone training method. Blended approaches that combine digital content delivery with periodic field sessions deserve testing in future rounds [7].

Practical Applications

Three recommendations follow from these results. First, extension programs targeting IPM adoption should prioritize farmer field schools or demonstration plots over lecture-only formats whenever budget and facilitator availability permit. Second, peer-to-peer mentoring offers a scalable alternative with strong long-term retention and should be considered where trained lead farmers are already present in the community. Third, mobile learning platforms should be used as supplements to field-based methods rather than replacements, with particular value for reinforcing record-keeping and economic assessment skills that benefit from digital tracking features.

Conclusion

This research compared five training methodologies for building IPM capacity among 312 smallholder farmers in Maputo province, Mozambique. Farmer field schools produced the highest knowledge gains and the strongest short- and long-term adoption rates across six IPM topic areas. Peer-to-peer mentoring showed promising adoption retention despite somewhat lower knowledge scores, while lecture workshops and mobile learning lagged on both measures. The results argue for shifting extension investment toward experiential, socially embedded training formats and using digital tools as complements rather than substitutes. Future work should assess the cost per adopter

across methods and test blended formats that combine field school sessions with mobile reinforcement modules to find the best balance of reach and effectiveness.

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