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EXTENSION-LED PARTICIPATORY MANAGEMENT OF PINK BOLLWORM IN COTTON UNDER A PUBLIC–PRIVATE PARTNERSHIP MODEL IN YAVATMAL DISTRICT OF MAHARASHTRA

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ABSTRACT:
An extension-led participatory programme was implemented during the year 2018–19 in Yavatmal district of Maharashtra through collaboration among Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, United Phosphorus Limited (UPL), Krishi Vigyan Kendra, Yavatmal and the State Agriculture Department. The programme comprised farmer training, field demonstrations, pest surveillance, pheromone-trap demonstrations, group meetings, individual advisories, farmer-to-farmer interaction and pesticide-safety awareness. Programme assessment covered 32 beneficiary farmers, while technology diffusion was assessed among 100 neighbouring farmers. Aggregate mean scores for knowledge, attitude, practical skill and adoption increased from 1.89, 2.17, 2.05 and 2.21 before the intervention to 3.93, 4.13, 4.05 and 4.14, respectively, after the intervention. The corresponding relative increases were 107.94, 90.32, 97.56 and 87.33%. The Knowledge Gain Index was 107.94%, and the composite Extension Effectiveness Index increased from 2.08 to 4.06. Among neighbouring farmers, mean scores for knowledge, attitude, skill and adoption were 3.64, 3.66, 3.67 and 2.32, respectively; 90% had moderate-to-high knowledge, 81% moderate-to-high attitude and 82% moderate-to-high skill scores. The average seed cotton yield among participating farmers was 24.18 q ha^{-1}, with gross return of ₹1,24,527 ha^{-1}, net return of ₹78,615 ha^{-1} and a benefit:cost ratio of 2.71. The results document favourable changes in the measured extension indicators and indicate the potential value of sustained field-based extension and farmer communication for disseminating integrated pink bollworm management. Because only aggregate scores were available, the changes are interpreted descriptively and are not presented as statistically significant treatment effects.

KEYWORDS: cotton; Pectinophora gossypiella; pink bollworm; participatory extension; integrated pest management; technology adoption; pesticide safety

1. INTRODUCTION

Cotton is an important commercial crop in Maharashtra and contributes substantially to the livelihood of farming households in the state. Cotton production is affected by several insect pests, among which pink bollworm, Pectinophora gossypiella (Saunders), remains a major constraint in several cotton-growing regions. The larval stage develops within flowers and bolls, where its concealed habit makes detection and management difficult once infestation is established. The increasing importance of pink bollworm in Indian cotton and the need for integrated management have been discussed in earlier studies (Kranthi et al., 2009; Birah et al., 2023).

Management of pink bollworm cannot rely exclusively on repeated insecticide applications. Timely monitoring, pheromone-based surveillance, removal of infested plant material and need-based insecticide application are important components of an integrated approach. Excessive dependence on insecticides may increase production costs and adversely affect beneficial organisms in the crop ecosystem. Farmer-participatory approaches to pink bollworm management have demonstrated the practical value of integrating management measures under field conditions (Birah et al., 2023).

The effectiveness of integrated pest management depends not only on the availability of technical recommendations but also on farmers' ability to identify the pest, monitor its incidence and make timely management decisions. Training, method demonstrations, field visits and individual advisories provide opportunities to translate technical information into field-level practice. Communication among farmers can further contribute to the spread of agricultural innovations beyond the initial group of programme participants (Rogers, 2003; Swanson and Rajalahti, 2010).

Collaborative programmes involving research institutions, extension agencies, private-sector organisations and farmers can provide a platform for combining technical expertise with field-level outreach. Against this background, the present study assessed an extension-led participatory programme for pink bollworm management implemented in Yavatmal district of Maharashtra. The assessment focused on changes in knowledge, attitude, practical skill and adoption among beneficiary farmers, diffusion indicators among neighbouring farmers, and the production and economic performance recorded in participating fields.

2. MATERIALS AND METHODS

2.1 Study area and programme implementation

The programme was implemented during 2018–19 in Yavatmal district of Maharashtra through collaboration among Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, United Phosphorus Limited (UPL), Krishi Vigyan Kendra, Yavatmal and the State Agriculture Department. The extension activities included farmer training programmes, method demonstrations, field visits, pest surveillance, pheromone-trap demonstrations, group meetings, individual advisories, farmer-to-farmer interaction, distribution of printed technical material and exposure activities. Pesticide-safety awareness formed part of the programme. The activities were designed to strengthen farmers' capacity to recognise pink bollworm, monitor pest incidence, understand recommended management practices and follow safe pesticide-handling procedures.

2.2 Respondents and assessment coverage

Thirty-two beneficiary farmers were included in the programme-impact assessment. Technology diffusion was assessed among 100 neighbouring farmers from Saykheda Khurd, Rui and Wai villages, as reported in the programme results. The assessment was field-based and used personal interaction and structured scoring. The available study records did not provide a detailed village-wise allocation of the 100 neighbouring respondents.

2.3 Data collection and assessment indicators

Information was obtained through personal interviews, structured questionnaires, field observations, group discussions and farmer interactions. Four dimensions were considered: knowledge, attitude, practical skill and adoption.

Knowledge assessment covered identification of pink bollworm, pest monitoring, economic threshold level, pheromone-trap use, integrated management and safe pesticide handling. Attitude was assessed in relation to integrated pest management, avoidance of unnecessary insecticide use and safe pesticide handling. Practical skill assessment covered installation of pheromone traps, preparation of spray solutions, calibration of spraying equipment, use of personal protective equipment and recognition of pink bollworm symptoms. Adoption assessment covered implementation of recommended practices, including pheromone-trap installation, destruction of infested flowers, ETL-based insecticide application, use of protective equipment and safe disposal of pesticide containers.

The indicators were assessed before and after implementation of the programme. The dataset available for analysis contained aggregate mean scores for the beneficiary group rather than individual farmer-wise paired observations. The instrument's item count, full response anchors, reliability coefficient and respondent-level score sheets were not available in the dataset used for this analysis.

2.4 Statistical analysis

The data were analysed descriptively. Absolute change was calculated as the post-project mean minus the pre-project mean. Relative increase was calculated as [(post-project mean − pre-project mean)/pre-project mean] × 100. The Knowledge Gain Index (KGI) was calculated using the same relative-change expression applied to the mean knowledge score. The composite Extension Effectiveness Index (EEI) was calculated as the arithmetic mean of the four component scores: knowledge, attitude, skill and adoption. The EEI was computed separately for the pre-project and post-project assessments.

Because only aggregate pre- and post-project means were available, the variance of paired differences could not be estimated. Accordingly, paired t-tests, standard errors, confidence intervals, P-values and respondent-level correlations were not calculated. These statistics cannot be validly derived from group means alone. The results are therefore presented as descriptive changes in the observed scores.

2.5 Economic analysis

Economic performance was described using cost of cultivation, gross return, net return and benefit:cost ratio. The reported values were expressed on a per-hectare basis. Net return was calculated as gross return minus cost of cultivation. The benefit:cost ratio was expressed as gross return divided by cost of cultivation. The available records did not provide separate treatment-wise or before-and-after expenditure data for individual plant-protection components.

3. RESULTS AND DISCUSSION

3.1 Socio-demographic profile of beneficiary farmers

Among the 32 beneficiary farmers, 62.5% belonged to the 31–40-year age group, and the mean age was 37.19 years. Illiterate respondents constituted 15.62%, while the remaining farmers had different levels of formal education. These characteristics indicate that the programme involved farmers from varied educational backgrounds. However, individual-level observations linking socio-demographic characteristics with adoption scores were not available; therefore, relationships between these characteristics and programme outcomes were not examined.

3.2 Changes in knowledge, attitude, skill and adoption

The mean scores for all four assessment dimensions were higher after programme implementation than before it (Table 1). Knowledge increased from 1.89 to 3.93, an absolute increase of 2.04 score units and a relative increase of 107.94%. The attitude score increased by 1.96 units (90.32%), while practical skill increased by 2.00 units (97.56%). The adoption score increased by 1.93 units, corresponding to a relative increase of 87.33%.

Indicator	Before programme	After programme	Absolute change	Relative increase (%)
Knowledge	1.89	3.93	2.04	107.94
Attitude	2.17	4.13	1.96	90.32
Practical skill	2.05	4.05	2.00	97.56
Adoption	2.21	4.14	1.93	87.33

The increase across the four dimensions is consistent with the programme's combination of technical training and field-oriented activities. Training provided information on pest identification and management, while demonstrations and field interactions offered opportunities to observe recommended practices. Pest surveillance, pheromone-trap demonstrations and individual advisories also provided repeated contact with the subject. Similar extension-related constraints and adoption patterns among cotton growers have been reported from the Vidarbha region (Mane et al., 2020; Dupare and Mazhar, 2023).

The observed increases should be interpreted as changes in the aggregate mean scores recorded before and after the programme. In the absence of respondent-level data and an independent comparison group, the analysis does not establish statistical significance or isolate the programme effect from other influences operating during the period.

3.3 Knowledge Gain Index

The Knowledge Gain Index was calculated from the mean knowledge scores as follows:

$$\mathbf{KGI = [(3.93 - 1.89) / 1.89] \times 100 = 107.94\%}$$

The KGI of 107.94% represents the relative increase in the mean knowledge score over its pre-programme value. It does not represent the proportion of farmers attaining complete knowledge or the percentage of farmers adopting the recommended practices.

3.4 Extension Effectiveness Index

The composite Extension Effectiveness Index was calculated as the arithmetic mean of knowledge (K), attitude (A), skill (S) and adoption (Ad) scores:

$$\mathbf{EEI = (K + A + S + Ad) / 4}$$

Before programme implementation, EEI = (1.89 + 2.17 + 2.05 + 2.21) / 4 = 2.08. After implementation, EEI = (3.93 + 4.13 + 4.05 + 4.14) / 4 = 4.06. The increase from 2.08 to 4.06 indicates that the improvement in the aggregate assessment was observed across all four measured dimensions rather than knowledge alone. Since the index is derived from aggregate means, the difference is descriptive and is not accompanied by a test of statistical significance.

3.5 Technology diffusion among neighbouring farmers

The diffusion assessment covered 100 neighbouring farmers from Saykheda Khurd, Rui and Wai. The programme records indicated that 90% of respondents had moderate-to-high knowledge scores, 81% had moderate-to-high attitude scores and 82% had moderate-to-high practical skill scores. Mean scores were 3.64 for knowledge, 3.66 for attitude, 3.67 for skill and 2.32 for adoption (Table 2).

Assessment dimension	Mean score
Knowledge	3.64
Attitude	3.66
Practical skill	3.67
Adoption	2.32

Knowledge, attitude and skill scores were similar in magnitude, whereas the mean adoption score was lower. This pattern suggests that awareness and reported practical understanding may have extended beyond direct programme beneficiaries more readily than the full implementation of recommended practices. Adoption of pest-management technologies may also depend on input availability, cost, labour requirements, perceived risk and confidence in the expected benefit. Dupare and Mazhar (2023) reported associations between extension-related and socio-economic factors and adoption of pink bollworm IPM technologies among cotton growers in Nagpur district.

The neighbouring-farmer scores provide descriptive evidence of technology awareness and reported adoption in the surveyed group. The exact number of neighbouring farmers adopting each individual practice was not available; therefore, a numerical Technology Diffusion Ratio could not be calculated. Similarly, practice-wise adoption counts were not available to derive a separate percentage-based Adoption Index. The mean adoption score of 2.32 is therefore retained as a score and is not relabelled as an adoption percentage or index.

3.6 Economic performance

The average cost of cultivation, including plant-protection expenditure, was ₹45,912 ha^{-1}. Seed cotton yield ranged from 10.83 q ha^{-1} under rainfed conditions to 34.00 q ha^{-1} under irrigated conditions, with an overall mean of 24.18 q ha^{-1}. The average gross return was ₹1,24,527 ha^{-1} and the net return was ₹78,615 ha^{-1}. The benefit:cost ratio was 2.71 (Table 3).

Economic parameter	Reported value
Cost of cultivation (₹ ha^{-1})	45,912
Seed cotton yield (q ha^{-1})	24.18
Yield range (q ha^{-1})	10.83–34.00
Gross return (₹ ha^{-1})	1,24,527
Net return (₹ ha^{-1})	78,615
Benefit:cost ratio	2.71

The reported net return is arithmetically consistent with gross return minus cost of cultivation (₹1,24,527 − ₹45,912 = ₹78,615). The benefit:cost ratio calculated as gross return divided by cost of cultivation is approximately 2.71. These figures indicate favourable overall farm-level economic performance among the participating farmers. Comparable positive production and economic outcomes under farmer-participatory pink bollworm management have been reported by Birah et al. (2023).

The available economic records do not include a separate treatment-wise or before-and-after account of expenditure on each plant-protection component. Consequently, the reported profitability cannot be attributed specifically to reduced pesticide use or to any single component of the extension programme.

3.7 Pesticide safety awareness and public-health significance

The importance of pesticide-safety education was particularly evident in Yavatmal district, which experienced a severe pesticide-poisoning crisis in 2017, when 21 farmers and farm labourers reportedly lost their lives following pesticide exposure. Government investigations highlighted unsafe pesticide-handling practices, including unscientific insecticide mixtures and inadequate protective measures. Against this background, the extension programme emphasised judicious pesticide use, avoidance of hazardous tank mixtures, use of personal protective equipment and safe spraying practices. Notably, no case of pesticide poisoning associated with spraying or related fatality was reported from the experimental village during the programme period, despite the continuing reports of pesticide-related hospital admissions elsewhere in the district. This observation underscores the relevance of sustained, field-based extension education in promoting safer pesticide-handling practices among farming communities.

3.8 Extension processes and implications for technology dissemination

The programme combined several extension methods, including farmer training, method demonstrations, pest surveillance, pheromone-trap demonstrations, field visits, group meetings and individual advisories. Such a combination can support learning by providing both technical information and opportunities for practical observation. Farmer-to-farmer interaction may further extend communication beyond the farmers directly involved in the programme, consistent with the role of interpersonal communication in the diffusion of agricultural innovations (Rogers, 2003).

The higher mean scores recorded among neighbouring farmers for knowledge, attitude and skill, relative to their adoption score, underline the distinction between awareness and implementation. Continued field follow-up, access to recommended inputs and timely decision support may be important for translating information into consistent field practices. The present assessment documents the pattern of scores in the surveyed groups but does not establish the independent causal contribution of each extension activity.

4. LIMITATIONS

The assessment involved 32 beneficiary farmers and 100 neighbouring farmers in the surveyed villages. The beneficiary impact dataset comprised aggregate pre- and post-programme means rather than individual farmer-wise observations. Consequently, the variability of individual responses and the distribution of paired changes could not be estimated, and inferential tests such as paired t-tests, confidence intervals and respondent-level correlation analyses were not appropriate. The study did not include an independent untreated comparison group. Details required to reproduce the scoring instrument fully, including the complete item schedule and its reliability assessment, were not available in the analysed dataset. Practice-wise adoption counts and the exact number of neighbouring farmers adopting specific practices were also unavailable; hence, separate Adoption Index and Technology Diffusion Ratio estimates were not derived. Economic records did not permit isolation of the financial contribution of reduced pesticide expenditure. Finally, the pesticide-safety record concerned reported fatalities and did not provide systematic information on non-fatal poisoning incidents.

5. Conclusion

The extension-led participatory programme implemented in Yavatmal district combined farmer training, field demonstrations, pest surveillance, pheromone-trap demonstrations, group interaction, individual advisories and pesticide-safety awareness to promote integrated pink bollworm management in cotton. Aggregate mean scores increased after programme implementation for knowledge (1.89 to 3.93), attitude (2.17 to 4.13), practical skill (2.05 to 4.05) and adoption (2.21 to 4.14). The Knowledge Gain Index was 107.94%, while the composite Extension Effectiveness Index increased from 2.08 to 4.06. Among neighbouring farmers, mean knowledge, attitude and skill scores were higher than the mean adoption score, indicating that dissemination of information and practical understanding did not necessarily translate into equivalent levels of reported implementation. Participating farmers recorded an average seed cotton yield of 24.18 q ha^{-1} and a benefit:cost ratio of 2.71. Overall, the findings support the practical relevance of sustained, field-based and participatory extension for disseminating integrated pink bollworm management. The magnitude and statistical significance of the observed changes, however, cannot be established from aggregate mean scores alone.

ACKNOWLEDGEMENTS

The authors express their sincere gratitude to Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, for institutional support during implementation of the programme. The authors also acknowledge the collaboration of United Phosphorus Limited (UPL), Mumbai, the State Agriculture Department, Yavatmal, Krishi Vigyan Kendra, Yavatmal, and the participating cotton growers for their cooperation and field-level support.

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