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Integrated management of fall armyworm (*Spodoptera frugiperda*) in maize: Insight from on farm trials

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Abstract

Fall armyworm (*Spodoptera frugiperda* J.E. Smith) has emerged as a major invasive pest in Indian maize cultivation, causing considerable yield reductions and compelling farmers to rely extensively on chemical insecticides. To assess the effectiveness of an Integrated Pest Management (IPM) strategy under real farming conditions, on-farm trials were carried out during the Rabi seasons of 2021–22 and 2022–23 in Pali Taluka and Beed district, Maharashtra. The study compared the conventional practice of chlorpyrifos application with an IPM module that included pheromone trap deployment and insecticide sprays based on pest monitoring. The results demonstrated that the IPM module markedly lowered plant infestation to 14.5%, compared with 42.65% under farmers' conventional practice, resulting in a pooled reduction of 65.99%. Additionally, the IPM approach achieved higher pooled grain yields (51.8 q ha⁻¹) and benefit–cost ratios (1.91) than traditional methods. These findings indicate that adopting IPM strategies offers an effective, economically feasible, and environmentally safer solution for sustainable fall armyworm management in maize.

Keywords: Fall armyworm, IPM, maize, pheromone trap, grain yield, benefit–cost ratio

Introduction

Maize (*Zea mays* L.) is a key cereal crop in India, contributing to food security, livestock feed, and agro-industrial applications. Its high productivity, adaptability, and diverse uses make it one of the most widely cultivated cereals across various agro-climatic zones (ICAR, 2020) [4]. Growing demand for maize, driven by its use in poultry feed, starch, ethanol, and processed food industries, has increased pressure on production. However, maize yields are often constrained by biotic stresses, particularly insect pests.

The fall armyworm (*Spodoptera frugiperda* J.E. Smith) has become one of the most destructive invasive pests affecting maize. Native to tropical and subtropical regions of the Americas, this highly polyphagous pest feeds on over 80 plant species (Goergen *et al.*, 2016) [2]. First detected in India in 2018, it has rapidly spread across major maize-producing states, severely impacting cultivation (Sharanabasappa *et al.*, 2018) [9]. Larval feeding damages whorl leaves, tassels, and developing ears, resulting in defoliation, stunted growth, and poor cob development.

Research indicates that heavy infestations during early crop stages can reduce yields by 20–60%, depending on pest density and crop stage (FAO, 2018; Hruska, 2019) [1, 3]. Larvae often feed concealed within whorls, complicating management, especially in smallholder farms. Farmers typically respond with repeated, indiscriminate applications of broad-spectrum insecticides, which often lead to ineffective pest control, increased cultivation costs, insecticide resistance, and loss of natural enemies (Hruska, 2019) [3]. Overuse of chemical insecticides also raises environmental and health concerns and threatens the sustainability of maize systems, highlighting the need for alternative, eco-friendly, and economically viable pest control strategies.

Integrated Pest Management (IPM) is recognized as a sustainable and effective approach to controlling fall armyworm. IPM combines pest monitoring (e.g., pheromone traps), cultural practices, biological controls, and selective, need-based insecticide applications to minimize crop damage while conserving beneficial organisms (FAO, 2018) [1]. Pheromone traps facilitate early detection and timely intervention, while selective insecticides, such as spinetoram,

effectively target fall armyworm larvae with limited impact on non-target species.

Krishi Vigyan Kendras (KVKs) play a critical role in evaluating and promoting improved crop protection technologies through on-farm trials (OFTs), providing insights into field-level performance, adaptability, and economic feasibility relative to existing farmers' practices. This study aimed to assess the performance of an IPM module for fall armyworm in maize, evaluating its effects on pest infestation, grain yield, and benefit–cost ratio compared with conventional farming practices.

Materials and Methods

On-farm trials were conducted by Krishi Vigyan Kendra, Khamgaon Beed-II, on farmers' fields in Pali Taluka and Beed district, Maharashtra, during the Rabi seasons of 2021–22 and 2022–23. The study sites are situated in a semi-arid region with medium-textured soils, warm tropical climate, and annual rainfall of 600–700 mm, mostly during the southwest monsoon. Average temperatures during the crop season ranged from 18 to 34 °C.

Trials included 10 farmers' fields, each with a 0.4-hectare plot, under standard farming conditions. Two treatments were compared:

- **T₁:** Farmers' conventional practice using chlorpyrifos at 20 ml per 10 liters of water.
- **T₂:** Improved IPM strategy involving pheromone trap installation (15 traps per hectare) for adult monitoring, followed by two applications of spinetoram 11.7% SC at 5 ml per 10 liters of water, 15 days apart. Thiamethoxam 12.6% + lambda-cyhalothrin 9.5% at 0.5 ml per liter was applied as an alternative based on pest pressure.

All agronomic practices were kept uniform across treatments following recommended maize cultivation practices. IPM interventions were initiated immediately after fall armyworm detection.

Observations

Infestation was monitored at regular intervals by counting affected plants among 100 randomly selected plants per plot. Cumulative infestation percentages were calculated for each season and pooled across two years. Pest reduction relative to conventional practice, grain yield (q ha⁻¹), and benefit–cost ratio (BCR) were recorded.

Data Analysis

Data from multiple farmers' fields were pooled and analyzed statistically. Mean yield and economic returns were compared between treatments to evaluate IPM performance. Two-year pooled data underwent statistical analysis to determine significant differences between treatments.

Results and Discussion

The efficacy of the Integrated Pest Management (IPM) module against fall armyworm (*Spodoptera frugiperda*) in maize was evaluated using percent plant infestation, grain yield, and economic returns under on-farm conditions (Table 1). The results clearly indicated that the IPM module was significantly superior to farmers' practice in reducing fall armyworm

infestation in both years of experimentation.

During 2021–22, farmers' practice involving chlorpyrifos application recorded a mean plant infestation of 44.6%, whereas the IPM module significantly reduced infestation to 14.4%. Similarly, in 2022–23, infestation levels were 40.7% under farmers' practice and only 12.6% under IPM treatment. The pooled analysis revealed that the IPM module restricted fall armyworm infestation to 14.5%, representing a 65.99% reduction over farmers' practice (42.65%).

The effective suppression of fall armyworm under the IPM module may be attributed to the integration of pheromone-based monitoring and timely application of selective insecticides. Installing pheromone traps enabled early detection of adult moth activity, facilitating need-based insecticide sprays at the most vulnerable larval stages. The effectiveness of spinetoram 11.7% SC in controlling lepidopteran pests has been well documented, owing to its novel mode of action and rapid knockdown of larvae. Similar findings were reported by Sharanabasappa *et al.*, (2018) ^[9] and Hruska (2019) ^[3], who emphasized the role of selective insecticides in managing concealed feeders like fall armyworm.

The present findings align closely with earlier studies reporting significant reductions in fall armyworm infestation through IPM strategies that combine monitoring tools and selective insecticides (FAO, 2018; Prasanna *et al.*, 2018) ^[1, 7]. Recent studies have also shown that newer insecticide molecules such as spinetoram, chlorantraniliprole, and spinosad are more effective against fall armyworm than older conventional insecticides, which often fail to provide satisfactory control due to resistance and poor coverage (Vani Sree *et al.*, 2024; Ramesh Naik *et al.*, 2024) ^[10, 8].

Grain yield data further supported the effectiveness of the IPM module. During 2021–22, the IPM plots recorded a grain yield of 45.2 q ha⁻¹, compared with 28.6 q ha⁻¹ under farmers' practice. In 2022–23, yields of 58.4 q ha⁻¹ and 42.3 q ha⁻¹ were recorded under IPM and farmers' practice, respectively. The pooled grain yield under IPM (51.8 q ha⁻¹) was significantly higher than that under farmers' practice (35.45 q ha⁻¹). The higher yield under IPM can be attributed to reduced pest pressure during critical crop growth stages, leading to improved plant vigour and better cob development.

The economic analysis showed that the IPM module was more profitable than farmers' practice. The benefit–cost ratio under IPM was 1.86 and 1.97 in 2021–22 and 2022–23, respectively, with a pooled BCR of 1.91, compared with 1.77 under farmers' practice. Although the IPM module involved a slightly higher initial investment, the higher yield and reduced crop damage led to higher net returns. Similar improvements in profitability from IPM adoption have been reported by Omprakash *et al.*, (2020) ^[6] and Lunagariya *et al.*, (2020) ^[5], highlighting the economic viability of integrated approaches for fall armyworm management.

Overall, the results of the present study corroborate earlier findings that underscore the importance of integrating pest monitoring tools with the judicious use of selective insecticides for the sustainable management of fall armyworm in maize. The consistent performance of the IPM module across two seasons under farmers' field conditions demonstrates its practical feasibility and suitability for large-scale adoption.

Table 1: Impact of On Farm Trial on Fall Armyworm in maize

Treatment	Plant Infested (%)			Reduction over FP (%)	Grain Yield (q ha ⁻¹)			BCR		
	2021–22	2022–23	Pooled	Pooled	2021–22	2022–23	Pooled	2021–22	2022–23	Pooled
T ₁ – Farmers’ Practice (Chlorpyrifos @ 20 ml/10 L)	44.6	40.7	42.65	–	28.6	42.3	35.45	1.64	1.90	1.77
T ₂ – IPM Demonstration (Pheromone traps + Spinetoram)	14.4	12.6	14.5	65.99	45.2	58.4	51.8	1.86	1.97	1.91

Conclusion

Over two years of on-farm trials, the Integrated Pest Management (IPM) approach demonstrated superior performance over conventional farmers’ practices in managing fall armyworm in maize. The combination of pheromone traps and timely, targeted insecticide applications reduced pest infestation by 65.99% and boosted grain yields to 51.8 q/ha compared with traditional methods. In addition, the IPM strategy improved economic returns, achieving a benefit–cost ratio of 1.91. These results highlight that adopting IPM offers an effective, economically viable, and environmentally safer solution for fall armyworm management in maize.

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