# Comparative Study of Cotton Varieties Against Pink Bollworm Infestation Monitored by Pheromone Traps

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A R T I C L E I N F O

A B S T R A C T

Known as "white gold," cotton (Gossypium spp.) is a key cash crop in Pakistan, particularly in Sindh and Punjab, where it fuels the textile industry and makes a substantial economic contribution to the country. One of its most damaging pests is the pink bollworm (Pectinophora gossypiella), which reduces yield and lint quality by feeding on the growing bolls. This study was conducted Plant Protection Research Institute, Tandojam. this study was to monitor pink bollworm populations in three cotton varieties, Koonj, Shahzadi, and Sindh-1, using pheromone traps during the flowering to early boll formation stage. A total of nine pheromone traps, three per variety, were installed in a randomized complete block design, with moth catches recorded daily and summarized weekly. results showed that Koonj recorded the highest mean catches (week 1: 12, week 2: 15, week 3: 18, week 4: 11 moths/trap), followed by Shahzadi (10, 12, 14, 9 moths/trap), while Sindh-1 had the lowest (6, 8, 9, 5 moths/trap). Peak moth activity occurred in the third week of July, coinciding with peak flowering, after which catches declined as boll development progressed. The findings highlight the effectiveness of pheromone traps as an eco-friendly tool for early detection and monitoring of pink bollworm, enabling timely pest management decisions and supporting sustainable cotton production. This research provided practical experience in trap installation, pest scouting, accurate data recording, and population trend analysis, reinforcing the importance of integrated pest management (IPM) practices.

## INTRODUCTION

Among the world's fiber crops, cotton (Gossypium hirsutum L.) occupies a special place and is frequently referred to as "white gold" due to its social and economic significance (Shahrajabian et al., 2020). In addition to providing raw materials to the textile sector, it is essential to global trade and provides for the livelihoods of millions of rural communities (Kabish, 2023). Cotton is a key component of the agricultural economies of nations like China, India, and Pakistan, providing foreign exchange, jobs, and GDP (Arshad et al., 2022). Because it provides lint, seed oil, and other byproducts that support farming communities and the industrial basis, cotton is particularly valued in Pakistan as the foundation of the agricultural economy (Shuli et al., 2018).

Notwithstanding its significance, the crop has several difficulties, with insect pests continuing to be the most detrimental factor limiting output and quality (Begna, 2020). One of the worst insect pests of cotton in the world is the pink bollworm (Pectinophora gossypiella Saunders). This pest, which is native to Asia but is now widely distributed, damages flower buds, squares, and bolls (Sarwar, 2017). It is very difficult to detect and control because its larvae penetrate maturing fruiting bodies and feed internally on seeds and lint (Gupta, 2017). Chemical sprays frequently miss the larvae because of this covert feeding behavior, allowing the pest to live and proliferate (Adhikari, 2022). Infestations cause significant production losses that can range from 20% to more than 50% in extreme circumstances, as they not only lower seed viability and oil content but also deteriorate fiber quality (Mahapatra et al., 2019). Historically, farmers have used chemical pesticides to control pink bollworm. Although these pesticides offered temporary respite, overuse of them has led to several long-term problems (Najork et al., 2021). Excessive pesticide use is now frequently linked to major environmental dangers, the comeback of secondary pests, and the development of resistance in pink bollworm populations (Rao et al., 2021). Furthermore, bollworms were initially effectively suppressed by the introduction of Bt cotton; however, resistance to Bt toxins has since been reported, raising questions regarding the sustainability of this strategy (Razzaq et al., 2023). These drawbacks emphasize the need for safer, more environmentally friendly ways to control pink bollworm. Pheromone traps have become one of the most promising methods for Integrated Pest Management (IPM) (Rizvi et al., 2021). Synthetic pheromones imitate the chemical signals used by insects to communicate in order to draw particular species, typically males, to traps (Abd El-Ghany, 2020). Pheromone traps for pink bollworm have shown themselves to be extremely sensitive and species-specific, which enables them to detect even very small populations in the field (Staten & Walters, 2021). Farmers can identify the beginning of pest activity, population accumulation, and seasonal peaks by tracking trap captures. This enables prompt interventions before significant crop loss occurs (Mariappan et al., 2025). This early-warning function helps direct focused management techniques and minimizes needless pesticide applications. Pheromone-based methods can aid in population suppression in addition to monitoring. High concentrations of pheromone dispensers placed in fields might make it difficult

for males to find females, which can disrupt mating and lower the number of pest generations in the future (Benelli et al., 2019). This tactic, called mating disruption, has proven effective in a number of cropping systems and is currently being suggested more and more as a component of cotton IPM initiatives. Pheromone traps are a good fit for sustainable pest management systems since they are non-toxic, economical, and safe for the environment (Shang et al., 2024).

## LITERATURE REVIEW
### Importance of Cotton

Cotton (Gossypium hirsutum L.) is widely acknowledged as one of the most significant fiber crops and is frequently referred to as "white gold" because of its enormous impact on international trade, industry, and agriculture (Khan et al., 2020). It supplies the main raw material for the textile industry, which is a vital component of many national economies, especially in the US, China, India, and Pakistan (Alvi & Shahid, 2018). Cottonseed is essential for human and animal nutrition since it is a valuable source of edible oil and livestock feed in addition to fibre. By creating jobs in growing, harvesting, ginning, spinning, and clothing production, the crop supports millions of farming families and ensures socioeconomic stability and rural lifestyles (Kumar, 2018). Additionally, cotton exports bring in a sizable amount of foreign income, and its byproducts, like seed cake and linters, find application in a wide range of sectors, including food, paper, and pharmaceuticals. Cotton is therefore a strategic crop having broad implications for economic growth and international trade in addition to being an agricultural commodity (Arude, 2023).

### Role of Pink Bollworm in Cotton

One of the worst insect pests of cotton in the world is the pink bollworm (Pectinophora gossypiella Saunders). Its larvae impair yield and fibre quality by boring into cotton fruiting bodies and eating on seeds and lint (Bhute et al., 2023). Management is particularly difficult since the larvae remain concealed from contact insecticides because they develop inside squares and bolls (Rajendran et al., 2018). Infestations cause significant financial losses for cotton growers by reducing not only the oil content and seed viability but also the lint's spinning value (Bitew & Abate, 2024). Yield losses of 20–50% have been documented in fields that are severely infected. Additionally, the pest is extremely adaptable, able to thrive in a variety of cotton-growing conditions, and persistent, posing a constant danger to sustainable cotton production (Ahmad et al., 2020).

### Role of Pheromone Technology in Pest Management

A more sustainable method of controlling insects is pheromone-based management. Insects communicate by chemical signals called pheromones, especially when locating potential mates (Guerrero & Reddy, 2023). To draw and catch male pink bollworm moths, traps are equipped with synthetic pheromone lures that are made to resemble the natural sex pheromone of females. This technology can identify even tiny pest populations, is very species-specific, and is harmless to the environment (Ambia, 2023). The primary

applications of pheromone traps are mass-trapping and monitoring. Monitoring traps yield important data on population peaks, seasonal activity, and pest incidence (Luo et al., 2019). Instead of depending on frequent insecticide spraying, this enables farmers to apply timely and focused control methods. Furthermore, pheromone traps can be utilized at large densities to limit pest populations by reducing successful mating, which lowers the number of pest generations in the future (Miller & Gut, 2015).

**Influence of Cotton Varieties on Pest and Trap Performance**

Pink bollworm and other insect pests' behavior and population dynamics are greatly influenced by the traits of their host plants. Cotton types differ in morphological characteristics such as canopy structure, plant height, trachoma density, and boll distribution, which can influence pest activity in fields (Belachew et al., 2024). Likewise, biochemical characteristics such as gossypol levels and volatile chemicals can affect the attraction or deterrence of pests. By changing how moths react to artificial pheromone signals, these varietal variations may also have an indirect impact on the effectiveness of pheromone traps (Gogi et al., 2017). Relatively few studies have evaluated the efficacy of pheromone traps across several cotton kinds under consistent field settings, even though research on trap efficiency is widely known. Although some studies imply that variations in canopy density and fruiting patterns cause variations in trap captures among types, these results are still erratic and need more thorough research (Saska et al., 2021).

**Integration of Pheromone Traps in IPM**

Since pheromone traps lessen the need for insecticides and encourage ecologically friendly activities, they are now frequently recommended as a component of Integrated Pest Management (IPM) programs (Romeh, 2018). Pink bollworm populations can be efficiently managed with pheromone traps in conjunction with cultural methods such as timely planting, crop residue clearance, and biological control (Mohan et al., 2014). Pheromone monitoring has become a common decision-making tool in a number of cotton-growing nations, enabling the use of pest control treatments only in cases where trap captures surpass threshold values (El-Wakeil & Abdallah, 2012).


**METHODOLOGY**

**Location and Duration**

The study was conducted at the Plant Protection Research Institute, Tandojam, Sindh. The field experiment was carried out from July 14 to August 13, 2025, during the flowering to early boll formation stage of cotton.

**Experimental Design and Crop Details**

Three cotton varieties, KOONJ, SHAHZADI, and SINDH-1, were selected for the study. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three treatments (varieties) and three replications on an area of 40 x 30 square feet. Each variety was planted in a separate plot under standard agronomic practices at Plant Protection research experimental fields.

**Pheromone Trap Installation**

For pink bollworm monitoring, nine pheromone traps (three traps per variety) were installed. Traps consisted of plastic delta traps equipped with

sticky liners and pink bollworm-specific synthetic sex pheromone lures. The traps were positioned at canopy height and spaced approximately 5 x 10 square feet within each plot to ensure adequate coverage.

**Monitoring and Data Recording**

Trap catches were recorded daily in the early morning hours to avoid lure scent degradation from heat. Captured moths were identified, counted, and removed to prevent recounting. Weekly mean catches per trap were calculated for each variety. The sticky liners were replaced weekly or earlier if saturated with dust or insects.

**Data Analysis**

Daily counts were summarized into weekly averages for each variety. Data were analyzed to determine population trends and peak moth activity during the study period. Observations were also correlated with crop phonology, particularly flowering and boll initiation stages, to interpret pest pressure in relation to crop development.

**RESULT AND DISCUSSION**

Daily moth counts from pheromone traps were recorded and converted into weekly averages for each variety. The results of the one-month monitoring period (July 14- 11 Aug)

Table 1. Weekly Average Moth (PBW) Catches per Trap in Different Cotton Varieties

| Week | Crop Stage | KOONJ (moths/trap) | Shahzadi (moths/trap) | Sindh-1 (moths/trap) |
|---|---|---|---|---|
| Week 1 (14 – 20 July) | Early flowering | 12 | 10 | 06 |
| Week 2 (21– 27 July) | Full flowering | 15 | 12 | 08 |
| Week 3 (28 July– 3 Aug) | Peak flowering | 18 | 14 | 09 |
| Week 4 (4–11 Aug) | Flowering early ball set | 11 | 09 | 05 |

Moth catches gradually increased from Week 1 to Week 3, with the highest captures recorded in the third week of July (18 moths/trap in KOONJ, 14 in KOONJ, and 9 in SINDH-1). This peak coincided with peak flowering, when the crop is most attractive to pink bollworm adults for oviposition. By Week 4, moth activity declined across all varieties, likely due to the transition from flowering to early boll development, along with natural pest mortality and environmental factors. The results of pheromone trap monitoring over the one month (July–August) showed clear differences among the three cotton varieties in terms of pink bollworm (Pectinophora gossypiella) male moth catches. Koonj consistently recorded the highest catches throughout the observation period. This could be attributed to its morphological and physiological traits that may make it more attractive to pink bollworm moths for mating and oviposition. Factors such as flowering pattern, boll setting time, and plant volatiles could

influence moth attraction in this variety. Shahzadi showed intermediate catches during the study. Its moderate pest attraction may be due to a combination of factors, including crop stage synchronization with moth activity and a balanced plant canopy structure, which provides suitable but not excessive shelter for pest survival. Sindh-1 recorded the lowest catches. This variety possesses Bt gene expression, which targets bollworm larvae after egg hatch. While Bt does not directly affect adult moth attraction to pheromone traps, the variety's potentially lower larval survival rate could reduce the overall pink bollworm population buildup in the field over time, indirectly influencing adult catches. Additionally, differences in phonology and volatile emissions could further reduce moth presence. The variation in catches among varieties highlights the influence of varietal traits on pest incidence. It also underscores the importance of considering crop variety in designing Integrated Pest Management (IPM) strategies, particularly when relying on pheromone traps for pest monitoring.

When it comes to monitoring and controlling the pink bollworm (Pectinophora gossypiella) in cotton, pheromone traps are a crucial part of Integrated Pest Management (IPM) tactics. Effective monitoring of pest population dynamics is made possible by these traps, which use synthetic sex pheromones to replicate the natural chemical signals generated by female moths to attract males (Alam et al., 2023). Because of its affordability, environmental safety, and capacity to identify pest activity at low population levels, pheromone-based monitoring is a common practice in cotton pest surveillance programs in Sindh, Pakistan, particularly in study sites like Tandojam (Ray & Mohanty, 2025). According to Sindh studies, the highest pink bollworm catches can occur at different times depending on environmental conditions and crop growth stages, with early monitoring allowing timely interventions before larval entry into the bolls (Peters, 2004). Pink bollworm using pheromone traps during the early to flowering stages of cotton provides crucial information on the initial infestation period, peak moth activity, and seasonal population trends (Abbas et al., 2022). This is crucial for determining the optimal timing of control measures, thereby reducing crop damage and minimizing pesticide use. It has been observed that certain lure components, such as Z, Z-, and E,E- isomers of hexadecadienyl acetate, can successfully capture pink bollworm males in pheromone trap trials (Flint & Merkle, 1984). One important aspect affecting trap efficacy is deployment density; studies indicate that 16 to 30 traps per hectare yield dependable monitoring data, with greater densities providing better detection during times when insect populations are low. Frequent trap catch monitoring (every three days) facilitates the identification of pest peaks and allows for the prompt implementation of focused control measures (Kean & Stringer, 2019). Pheromone traps can also be used to compare the sensitivity of three cotton cultivars cultivated in Tandojam to pink bollworm from the early stages to flowering. Variations in moth catch statistics between types could be a result of differences in plant characteristics that affect pest preference, such as blooming phonology, boll retention, or chemical profile (Kadoić Balaško et al., 2020). Variety selection and the creation of regional IPM recommendations both

benefit from this information. By minimizing needless chemical applications, preserving natural enemies, and promoting environmental preservation, pheromone trap-based monitoring not only helps detect pink bollworm outbreaks early but also promotes sustainable pest management (Adamczyk & Lorenz, 2012). Pheromone trapping was a successful and environmentally responsible way to monitor and manage important insect pests of the cotton crop in July and August. According to Katranas et al. (2024), the traps were especially helpful in identifying male bollworm moths (such as Helicoverpa armigera, Pectinophora gossypiella, and Earias spp.) early on, allowing for prompt pest control options. Without heavily depending on chemical insecticides, this technique could help reduce damage to cotton bolls and improve crop health, as seen by the decrease in pest incidence in the pheromone trap-monitored plots. Additionally, pheromone traps offered data for ongoing monitoring, which aided in comprehending the dynamics of pest populations in connection to cropping season environmental factors (Preti et al., 2021). However, trap density, lure quality, and appropriate field placement can all affect how successful pheromone traps are. Cotton farming's sustainability and pest control may be further improved by combining pheromone traps with other Integrated Pest Management (IPM) elements (Whitfield et al., 2019).

## CONCLUSIONS AND RECOMMENDATIONS

Pheromone traps are a selective, economical, and environmentally sound method of keeping an eye on and controlling cotton insect pests. When applied appropriately, the findings from observations conducted in July and August demonstrated their potential for both early pest outbreak detection and population reduction. Pheromone traps contribute to the preservation of beneficial insects, environmental protection, and sustainable cotton production by reducing the use of excessive pesticides. The efficiency of cotton pest management in Pakistan can be greatly increased by broader adoption of this technology, aided by farmer education and integration with IPM techniques.

Cotton farmers should be encouraged to use pheromone traps as a crucial part of Integrated Pest Management (IPM). By using them, farmers may detect pink bollworm activity early and take appropriate action before the insect infiltrates cotton bolls. Given that moth catches showed varietal heterogeneity, pest monitoring plans ought to be customized for each cotton type. For example, compared to Sindh-1, Koonj may need more stringent monitoring and early interventions due to its higher moth attractiveness. Training programs for farmers should be set up to enhance their abilities in data recording, pest detection, and trap placement. This will improve pheromone-based monitoring uptake and appropriate use.

## FURTHER STUDY

This research still has limitations, so further research on this topic is still needed.

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