Advances in Bioresearch
Adv. Biores., Vol 16 (4) July 2025: 474-478

Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
DOI: 10.15515/abr.0976-4585.16.4.474478

Advances in Bioresearch

ORIGINAL ARTICLE

Pest Incidence in Bt Cotton: Evaluating the Impact of Pink Bollworm in Nandurbar, Maharashtra

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ABSTRACT
The study examines the increasing vulnerability of genetically engineered Bt cotton to insect pests, particularly the pink bollworm (Pectinophora gossypiella), in the Nandurbar district of Maharashtra during. Despite the initial promise of Bt cotton to reduce pest damage and chemical pesticide usage, field observations revealed a high incidence of pest infestations, with 92.2% of Bt cotton fields affected by pink bollworm, along with significant occurrences of other pests and diseases, such as Alternaria leaf spots (91.3%) and mealybugs (92.6%). The research, conducted across 20 villages and involving 100 Bt and 20 non-Bt cotton farmers, employed rigorous sampling techniques to assess pest and disease impact. The findings highlight a concerning trend of declining genetic resistance in Bt cotton, leading to increased reliance on chemical pesticides and substantial economic losses for farmers, prompting a call for integrated pest management (IPM) strategies to ensure sustainable cotton production in the region.
Keywords: *Bt cotton, pink bollworm, pest resistance, integrated pest management, Maharashtra, economic loss, agricultural sustainability, cotton diseases.*

Received 19.05.2025 Revised 21.06.2025 Accepted 27.07.2025

How to cite this article:
Sandeep A. M and Amanulla K. Pest Incidence in Bt Cotton: Evaluating the Impact of Pink Bollworm in Nandurbar, Maharashtra. Adv. Biores., Vol 16 (4) July 2025: 474-478

INTRODUCTION

Genetically engineered crops have rapidly become a cornerstone in modern agriculture, primarily due to their enhanced ability to control insect pests and reduce crop damage. One such innovation is the development of transgenic crops, like cotton and maize, which have been engineered to produce toxins derived from *Bacillus thuringiensis* (Bt). These Bt crops were cultivated on approximately 12 million hectares globally by 2001, demonstrating their substantial adoption [1]. Despite their widespread usage, concerns remain regarding the long-term ecological and agricultural impacts of these genetically modified crops, particularly as insect resistance to Bt toxins continues to evolve [1, 2].

Cotton, a crop of immense global economic importance, is cultivated extensively across tropical and subtropical regions in over 70 countries, making it one of the most critical fiber crops worldwide (CABI). In India, cotton occupies a significant place within the agricultural landscape and is primarily grown across three major agro-ecological zones: the northern, central, and southern zones [3]. India ranks first in the world in terms of cotton acreage; however, its productivity remains lower compared to other leading cotton-producing nations [4]. For instance, during the 2017-18 growing season, cotton was cultivated over 12.43 million hectares in India, with an average productivity of 505.46 kg/ha [5].

In Maharashtra, Bt cotton varieties were first introduced in the 2001-02 growing season alongside the states of Gujarat and Andhra Pradesh. The adoption of Bt cotton increased rapidly in Maharashtra, replacing many traditional and hybrid cotton varieties across the state. Initially hailed for its promise to reduce the dependence on chemical pesticides, Bt cotton's performance soon came under scrutiny, as reports began to emerge of the need for increased pesticide use, even higher than with traditional cotton varieties [6].

A growing challenge for Bt cotton cultivation, particularly in India, has been the emergence of resistance in key insect pests. Chief among these is the pink bollworm (*Pectinophora gossypiella* Saunders)

(Lepidoptera: Gelechiidae), a notorious pest that has plagued cotton crops globally and is ranked as one of the six most destructive cotton pests in the world [7]. Since 2017, the resurgence of pink bollworm in India, particularly in the major cotton-growing regions, has posed severe ecological and economic threats [8]. Notably, in 2015, significant damage to bolls caused by pink bollworm was documented in Bollgard-II varieties in regions across Gujarat, and in some parts of Andhra Pradesh, Telangana, and Maharashtra [9].

MATERIAL AND METHODS

Study Area and Field Visits: Fild study was conducted in the Nandurbar district of Maharashtra during the 2022-23 cropping season as per modified methods of Roy and Najork *et al*., 2021 [6, 10, 11]. The region is a significant in medicinal plant and agriculture especially cotton-growing area where Bt cotton has been extensively adopted [12]. Field visits were carried out across 20 villages, involving 100 Bt cotton farmers and 20 non-Bt cotton farmers. These visits were designed to assess pest and disease incidence in both Bt and non-Bt cotton fields.

Sampling Design and Data Collection: To ensure representative sampling, the fields were selected based on variations in cotton varieties, cultivation practices, and geographical distribution. During the visits, detailed observations were recorded on the presence and severity of pink bollworm (*Pectinophora gossypiella*) infestations, along with other pests such as aphids, whiteflies, and bollworms.

Pest and Disease Scouting Techniques: Scouting for pink bollworm involved inspecting cotton bolls for signs of larval entry, feeding damage, and internal tunneling. Each field was divided into sections, and at least 20 randomly selected plants were examined per section for infestation.

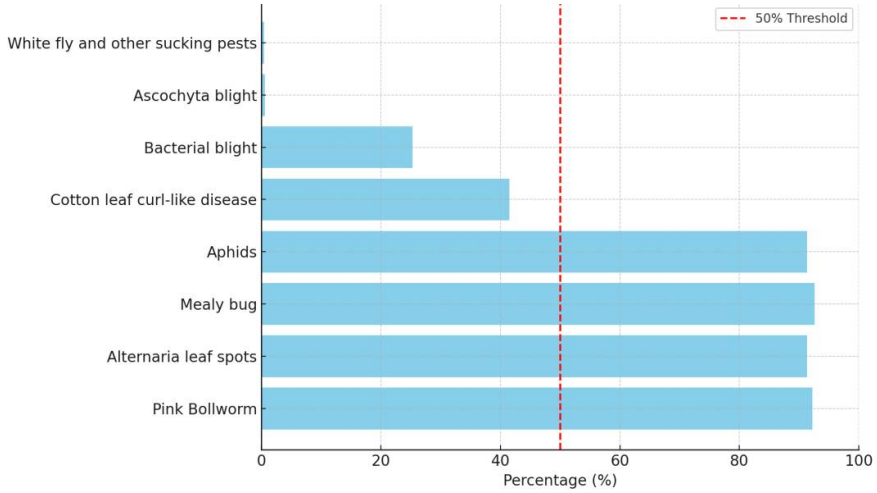
Survey of Farmer Perceptions: Farmers' perceptions were gathered through structured questionnaires focusing on their experiences with pest and disease outbreaks. Data on the timing and intensity of infestations, the effectiveness of pesticide use, and economic losses were collected.

Statistical Analysis: The collected data were analyzed using SPSS software. Descriptive statistics summarized pest and disease incidence, while inferential statistics evaluated the relationships between pest levels, geographical factors, and farming practices.

RESULTS AND DISCUSSION

Field Observations and Pest Incidence: Field observations in the Nandurbar district during the 2022-23 cropping season revealed that Bt cotton experienced a significantly higher incidence of pink bollworm (*Pectinophora gossypiella*) compared to non-Bt varieties. The survey indicated that 92.2% of Bt cotton fields were affected by pink bollworm with a high intensity, causing substantial economic losses to the farmers. Additionally, other pests and diseases such as *Alternaria* leaf spots (91.3%), mealybugs (*Phenacoccus solenopsis*) (92.6%), and aphids (*Mavatudtuda*) (91.3%) also exhibited high incidence rates in Bt cotton fields.

The most severe impact was observed in the tehsils of Nandurbar, Taloda, and Shahada, where almost the entire Bt cotton crop was affected by pink bollworm. In Shahada and Akkalkuwa, the majority of Bt cotton fields suffered from Alternaria leaf spots and mealybug infestations, with incidence rates reaching over 90% in all cases [13].

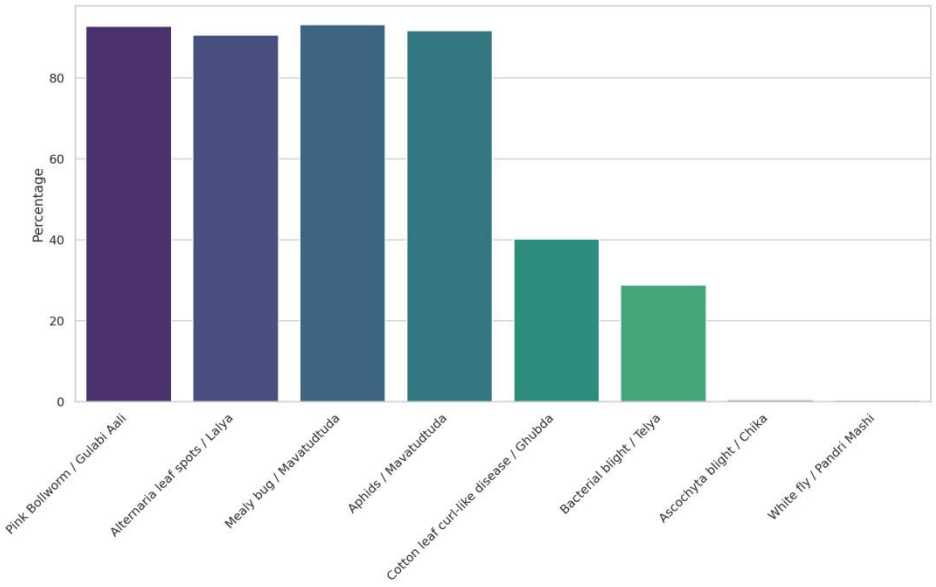


Graph 01: Incidence of Diseases / Worms in Bt cotton

Table 1: Type of Diseases/Worms and Their Incidence in Bt Cotton Fields during Kharif 2022-23

Sr. No.	Type of Diseases/Worms	Scientific Name	Local Name	Percentage (%)	Incidence
1	Pink Bollworm	*Pectinophora gossypiella*	Gulabi Aali	92.2	High
2	*Alternaria* leaf spots	*Alternaria* spp.	Lalya	91.3	High
3	Mealy bug	*Phenacoccus solenopsis*	Mavatudtuda	92.6	High
4	Aphids	*Aphis gossypii*	Mavatudtuda	91.3	High
5	Cotton leaf curl-like disease	Virus (CLCuD)	Ghubda	41.5	High
6	Bacterial blight	*Xanthomonas campestris*	Telya	25.3	Medium
7	*Ascochyta* blight	*Ascochyta gossypi*	Chika	0.6	Low
8	White fly and other sucking pests	*Bemisia tabaci*	Pandri Mashi	0.4	Low

Disease Incidence and Severity: In addition to pink bollworm, the study documented the presence of *Ascochyta* blight (0.6%) and bacterial blight (25.3%), both affecting Bt cotton with medium to low incidence. *Ascochyta* blight, caused by *Ascochyta gossypi*, and bacterial blight, caused by *Xanthomonas campestris*, were reported for the first time in Bt cotton fields in this region. While their prevalence was lower, they nonetheless contributed to the cumulative damage affecting the crop.



Graph 02: Incidence of diseases on Bt Cotton

Table 2: Tehsil-wise Appearance and Incidence of Pink Bollworm, Diseases, and Insect Pests

S. No.	Type of Worms, Diseases, Insects/Pests	Tehsil of the District (%)					
		Nandurbar	Shahada	Taloda	Akkalkuwa	Navapur	Akranimahal
1	Pink Bollworm / Gulabi Aali	92.8	94.2	93.6	90.5	91.1	90.7
2	*Alternaria* leaf spots / Lalya	90.6	91.4	89.6	92.2	90.4	94.1
3	Mealy bug / Mavatudtuda	93.2	95.2	92.4	90.3	92.6	92.8
4	Aphids / Mavatudtuda	91.7	90.4	90.6	93.3	90.8	91.2
5	Cotton leaf curl-like disease / Ghubda	40.2	44.1	45.2	41.6	39.4	38.7
6	Bacterial blight / Telya	28.8	24.1	27.4	22.6	23.1	27.2
7	*Ascochyta* blight / Chika	0.5	0.6	0.5	0.9	0.7	0.4
8	White fly / Pandri Mashi	0.4	0.4	0.5	0.4	0.3	0.5

DISCUSSION

The findings highlight a concerning trend regarding the vulnerability of Bt cotton to pests and diseases, particularly pink bollworm, despite the claims made by seed companies. The genetic resistance of Bt cotton, which was expected to protect against pests like pink bollworm, appears to have diminished, resulting in widespread infestations. The high incidence of sucking pests like aphids and whiteflies, alongside diseases such as *Alternaria* leaf spots, suggests that Bt cotton's resistance to pests is declining, necessitating the use of additional pesticides.

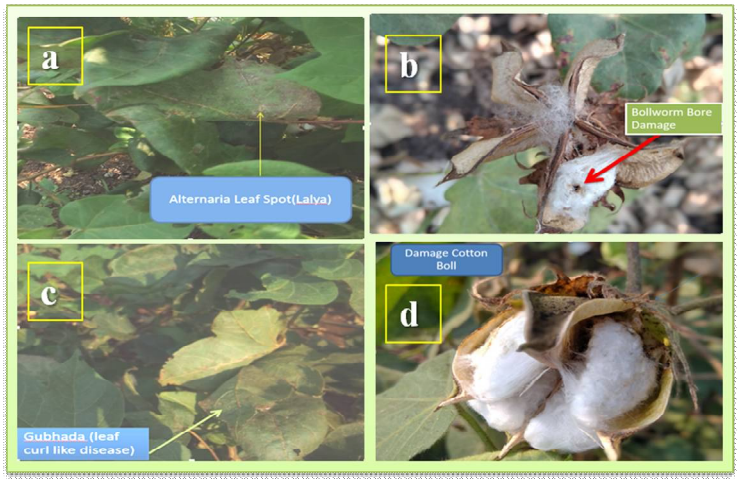


Fig: 01. Cotton Crop Infection

.(a) *Alternaria* leaf (b) Pink Bollworm damage (c) Cotton leaf curl-like disease / Ghubda and (d) Colton ball damage

The inter-tehsil variation in pest and disease incidence suggests that environmental and agronomic factors may influence the severity of infestations. However, the overall trend across the district shows that Bt cotton consistently harbored more pests and diseases than non-Bt cotton, challenging the effectiveness of current pest management strategies.

The increase in pesticide use to combat these challenges raises concerns about the long-term sustainability of Bt cotton cultivation in the region. The high input costs associated with chemical treatments, combined with reduced yields due to pest damage, are leading to decreased profitability for farmers, calling for an urgent re-evaluation of pest management practices in Bt cotton cultivation.

CONCLUSION

The study highlights the increasing vulnerability of Bt cotton to pests, especially pink bollworm (*Pectinophora gossypiella*), in the Nandurbar district during the Kharif 2022-23 season. Pink bollworm, which has developed resistance to Cry1Ac and Cry2Ab toxins, along with other pests and diseases like *Alternaria* leaf spots and aphids, has caused significant economic losses for farmers [14]. With a 30% reduction in cotton yields and rising pesticide costs, Bt cotton's economic viability in the district is declining.

This underscores the urgent need to reassess pest control strategies and adopt integrated pest management (IPM) approaches that reduce chemical pesticide use while enhancing crop resilience. Sustainable pest management practices tailored to local conditions are essential to protect the livelihoods of cotton farmers in Nandurbar.

ACKNOWLEDGMENT

The authors are sincerely thanks all the farmers of Nandurbar district for their invaluable support during this study. Special thanks to Prof. Dr. Vipul J. Somani for his guidance throughout the research. The authors are also extending gratitude to the trustees of the institute, Hon. Shri Motilal F. Patil and Hon. Shri Hiralal N. Patil, as well as the Principal and Management of Anjuman Islam Janjira Degree College of Science for their continuous encouragement.

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