



Incidence of Pink Bollworm *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) on Flowers (Rosette) of Bt Cotton in Andhra Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AAR and GMVP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript.

Authors VCBN and CHC managed the analyses of the study and edited manuscript. Authors VHV, AKP and VSR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The pink bollworm *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) has recently emerged as a serious menace on Bt cotton in India. Extensive roving surveys were conducted in 12 locations of three major cotton growing districts of Andhra Pradesh, India, to assess the level of pink bollworm infestation in Bt cotton during 2018-19 and 2019-20. The dynamics and severity of flower damage due to pink bollworm during the 60-135 days' crop period were evaluated based on a random

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sampling of flowers. Survey results revealed a widespread infestation of pink bollworm on Bt cotton flowers across the surveyed sites in a range of 11.8-19.50%. With the advancement of the crop season, a progressive increase in the flower damage was observed till 120 DAS then declined. Reasons for the enhanced flower damage and implications are discussed in this article.

Keywords: BT cotton; rosette flowers; pink bollworm; bollgard.

1. INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an essential commercial crop in India and Andhra Pradesh. It is a profitable crop grown mainly for fiber. Cotton is grown on 12.5 million hectares in India, with an output of 360 lakh bales (170 kg per bale) and productivity of 486 kg/ha (lint). Andhra Pradesh is the country's sixth-largest state in terms of area (5.86 lakh ha), seventh in terms of output (20 lakh bales with a productivity of 586 kg/ha), and occupying fourth in terms of production in India, 2019-20 [1]. Of the several factors contributing to the low yield of cotton, biotic constraints are important, of which the insect pests are vital. In this, the pink bollworm *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) has recently emerged as a severe concern to cotton production in India. The insect is native to the Indo-Pak region [2] and can be found in Tropical America, Africa, Asia, Australia, Egypt, the United States, and Mexico where cotton is cultivated. The pink bollworm (abbreviated as PBW) is a stenophagous insect that has co-evolved with Malvaceous food plants such as cotton, okra, Deccan hemp, and Roselle [3]. PBW larvae feed on cotton plant flowers, buds, bolls, and seeds, causing malformed flowers, premature opening and heavy shedding of infested bolls, decreased fiber length, and poor lint quality due to staining [4]. Before using broad-spectrum insecticides and the introduction of transgenic cotton, the pink bollworm was a major cotton pest in India, causing 20-90 percent yield losses [5]. Synthetic pyrethroids, which were first introduced in India in the 1980s, were crucial in combating this notorious and difficult-to-control cotton pest. On the other hand, the intensive use of chemical insecticides caused widespread ecological harm in the cotton climate, resulting in bollworm exacerbation and secondary pest problems [6-8]. Following that, the development of genetically engineered transgenic cotton containing genes encoding delta-endotoxin proteins from the entomopathogenic soil bacterium *Bacillus thuringiensis* opened up new avenues for the management of the dreaded cotton bollworm. Since then, the Indian cotton ecosystem has seen remarkable changes in its pest status. In 2002 and 2006, a single gene (Cry 1Ac) and dual gene (Cry

1Ac + Cry 2Ab) Bt cotton hybrids were commercially released in India [9], targeting the dreaded bollworm complex, which included the American bollworm *Helicoverpa armigera* (Hub.), spotted bollworm *Earias vitella* (Fab.) and PBW. Until 2009, Bt cotton technology performed well and offered promising boll-worm complex control. As a result, PBW infestations were very low in the first decade after Bt cotton was released. *H. armigera* and *E. vitella* still susceptible even after 15 years of continuous Bt cotton cultivation in India. However, PBW reappeared as a major pest problem in India's central and southern cotton-growing belt, a nearly two-decade hiatus. On these, the pest was confirmed to feed and thrive on single (Bollgard I) and dual (Bollgard II) Bt cotton genes. Due to a variety of off-season sources and an early occurrence on flower stage will favour the extent of damage and the problem became severe on Bt cotton during progressive crop growth stages. Under the circumstances, this investigation aims to record the incidence of Rosette flowers due to PBW on Bt cotton in three major cotton growing districts of Andhra Pradesh during 2018-19 and 2019-20.

2. METHODOLOGY

2.1 Sampling Plan for Survey and Assessment of PBW infestation

A survey was conducted to know the intensity of pink bollworm incidence on Bt cotton in Guntur, Prakasam, Kurnool districts of Andhra Pradesh in farmers' fields from September to January 2018-19 and 2019-20. A total of 12 mandals covering three major cotton growing districts of the state were surveyed from 6 to 135 days of the crop growth period. A random survey of villages having a large area under cotton was done. The sampling procedure accounted for flowers damaged for assessing PBW damage dynamics during the 60-135 days' crop period. For determining the flower damage due to PBW, destructive sampling from four mandals, i.e. Tadikonda, Amaravathi, Prathipadu, Pedanandipadu of Guntur district, Parchur, Inkollu, Martur, Ballikurva of Prakasam District and Nandyal, Bandiatmakur, Yemmigunur,

Mantralayam of Kurnool District. From each Mandal, 50 flowers from farmer fields were scrutinized. A total of 600 flowers were sampled at fortnight intervals, later converted to percent incidence for further study.

Sampled flowers were manually opened and examined for the presence of the PBW larvae. The infestation ratio was calculated by the percent of flowers infested per hundred flowers from each district of four mandals respectively and percent infestation for different locations was subsequently calculated.

2.2 Data Collection

The field infestation ratio or infected level of the field is calculated with the equation given below.

$$ILF = \frac{NIF}{NCF} * 100$$

ILF: Infected levels of field (%) or IR: Infestation Ratio

NIF: Number of infected flowers

NCF: Number of collected flowers

3. RESULTS AND DISCUSSION

3.1 Confirmation of the Identity of PBW

The morphological identification indicated that all the samples collected from the surveyed sites comprised single species, i.e., pink bollworm, *P. gossypiella*. The morphological identification of larvae, pupae, and adults was based on the descriptions of Saunders [2,10]. All the examined larvae were deep pink with head capsules dark brown and were found inside the infested (rosette) flowers (Plate 1, 2a). The newly formed pupae were light brown colored, which later turned to dark brown. The adult moths that emerged from all the collections were light brown coloured with undefined blackish spots on the forewings and silvery grey colored hindwings. The adult moths were identified as *Pectinophora gossypiella* based on morphological examinations. (Plate 2b).

3.2 Incidence in Flower Stage

Pink bollworm infestation has been reported from all surveyed districts: Guntur, Prakasam and Kurnool known as the cotton bowl of Andhra Pradesh.

The results about the pink bollworm incidence on cotton in three different cotton-

growing regions of Andhra Pradesh are presented in Tables 1 and 2. Data on percent rosette flowers was recorded starting from 60 DAS to 135 DAS in four different mandals in each district, and average incidence was calculated. A perusal of the roving survey results during 2018 *Kharif* indicated that rosette flowers' percent ranged from 2 to 39 during the crop growth period of 60-120 DAS. The lowest percent damage of two was recorded in Parchur mandal of Prakasam district at 60 DAS, and the highest infestation of 39% was recorded in Martur mandal of Prakasam district at 120 DAS. Further, a progressive increase in the average incidence was observed as the season progressed and reached a peak at 120 DAS, then declined. Low (<10%) to moderate (>10% to <20%) incidence was noticed during 60- 90 DAS, moderate to severe (>20%) incidence was recorded during 120-135 DAS. During the crop growth period, the average flower damage observed was highest in Martur (18.3%) mandal of Prakasam, followed by Nandyal (18.0%) and Tadikonda (16.8%) mandals of Kurnool and Guntur districts, respectively.

An examination of the roving survey results during 2019 *kharif* indicated that rosette flowers' percent ranged from 3 to 45% during the crop growth period. The lowest percent damage of three was recorded in the Yemmigunur mandal of Kurnool district and Parchur mandal of Prakasam district at 60 DAS, and the highest infestation of 45% was recorded in Amaravathi mandal of Guntur district at 120 DAS. A progressive increase in the average incidence was observed as the season progressed and reached a peak at 120 DAS, then declined. Low (<10%) to moderate (>10% to <20%) incidence was noticed during 60- 90 DAS, moderate to severe (>20%) incidence was recorded during 120-135 DAS. The average flower damage observed was highest in Nandyal (19.5%) mandal of Kurnool, followed by Tadikonda mandal of Guntur (19.0%) and Martur (18.8%) mandal of Prakasam district. Occurrence and extensive damage of PBW on Bt cotton in India in general and Andhra Pradesh State in particular has posed a serious concern to the country's cotton farming. Since the pest has regained its pestilence status against Bt cotton, a novel genetically engineered technology designed to fight the bollworm complex, the current investigation takes on new significance in this

sense. PBW, a supposed native of India, had already developed itself and adapted to the broader climatic conditions of India's significant cotton-growing tracts. Furthermore, due to its concealed biology/cryptic habitat and defense from insecticidal applications and natural enemies, a pest like PBW creates and perpetuates more quickly than other insect pests. As a result, PBW is classified as a tricky pest to control. Results based on extensive field surveys, revealed the widespread infestation of PBW in second-generation Bt cotton, i.e. Bollgard II in Andhra Pradesh, a major cotton-producing cotton state in Southern India. Strikingly, the pest had been recovered from all the 12 sampled locations spread across the three major cotton growing districts of Guntur, Prakasam and Kurnool of the State. During the 2018-19 season, the average damage to flowers was highest in Prakasam, 14.9%, followed by Kurnool, 14.8% and lowest in Guntur, 14.3% (Table.1). Likewise, during 2019-20 season the highest flower damage (rosette flowers) was recorded in Guntur, 16.3%, followed by Prakasam, 16.1%, and the lowest in Kurnool, 14.8% (Table.2).

The widespread incidence of PBW on Bt cotton flowers and bolls was recorded in different

cotton-growing tracts of Maharashtra, a key central Indian cotton-growing state [11]. Likewise, PBW incidence was reported from different agro-ecological zones of Karnataka, an important cotton-growing state from South India [12]. They reported flower damage to the extent of 6.5% during 2017-18 and 4.2% during 2018-19.

Of late, higher incidence levels were being observed on flowers. This may be mainly due to cotton cultivation during summer months by a more significant number of farmers, long term storage of raw cotton in ginning mills and market yards [13]. The present study indicated that increased PBW incidence in flowers (around 15%) paves the way for more PBW's second-generation population. This enhanced population buildup would cause havoc to the bolls during the later part of the season. Earlier studies [14] also indicated PBW incidence on Bt cotton (65 DAS -75 DAS) in different districts of Gujarat. Pink bollworm infestations was observed in flowers of different Bollgard II hybrids ranging from 1.32% in Surendranagar to 34% in Junagadh on various Bt cotton hybrids. The highest pink bollworm infestation on rosette flower was observed in Junagadh, Rajkot, and Ahmedabad.



Plate 1. PBW damage to the flowers of Bt cotton. (a) Rosetting of infested flower (b) Infested flower showing feeding damage and PBW larva (inside the circle)

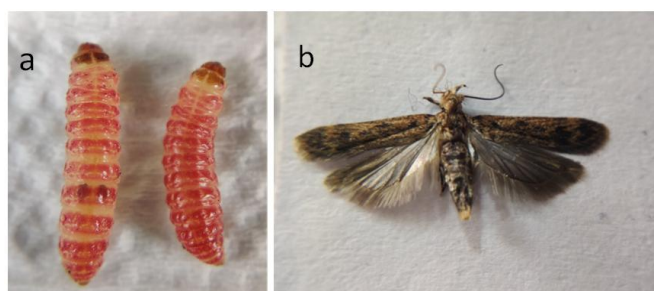


Plate 2. Morphological identification of Pink bollworm. (a)PBW larva (b) Adult moth

Table 1. Percent Pink bollworm infested flowers (Rosette flowers) in three major cotton growing districts of Andhra Pradesh (2018-19)

S. No.	District	Mandals	Percent PBW infested (Rosette) flowers						Average (IR)
			60 DAS	75 DAS	90 DAS	105 DAS	120 DAS	135 DAS	
1	Guntur	Tadikonda	6	8	11	18	38	20	16.8
		Amaravathi	4	7	9	16	37	17	15.0
		Prathipadu	4	7	8	16	31	14	13.3
		Pedanandipadu	3	6	7	14	30	11	11.8
	Average		4.25	7	8.75	16	34	15.5	14.3
2	Prakasam	Parchur	2	5	9	10	26	20	12.0
		Inkollu	5	8	11	11	29	21	14.2
		Martur	7	9	13	19	39	23	18.3
		Ballikurva	6	9	10	12	30	24	15.2
	Average		5	7.75	10.75	13	31	22	14.9
3	Kurnool	Nandyal	7	8	11	18	35	29	18.0
		Bandiatmakur	4	5	9	15	27	21	13.5
		Yemmigunur	3	5	7	14	25	20	12.3
		Mantralayam	5	6	9	16	31	25	15.3
	Average		4.75	6	9	15.75	29.5	23.75	14.8

IR – Infestation Ratio

Table 2. Percent Pink bollworm infested flowers (Rosette flowers) in three major cotton growing districts of Andhra Pradesh (2019-20)

S. No.	District	Mandals	Percent PBW infested (Rosette) flowers					Average (IR)	
			60DAS	75 DAS	90 DAS	105 DAS	120 DAS		135 DAS
1	Guntur	Tadikonda	6	9	13	20	42	24	19.0
		Amaravathi	6	10	12	13	45	19	17.5
		Prathipadu	5	9	11	17	34	17	15.5
		Pedanandipadu	4	8	7	16	30	14	13.2
	Average		5.25	9	10.75	16.5	37.75	18.5	16.3
2	Prakasam	Parchur	3	6	9	13	26	21	13.0
		Inkollu	6	9	13	14	32	23	16.2
		Martur	7	10	12	21	38	25	18.8
		Ballikurva	5	8	14	13	32	26	16.3
	Average		5.25	8.25	12	15.25	32	23.75	16.1
3	Kurnool	Nandyal	7	8	12	19	37	34	19.5
		Bandiatmakur	4	5	10	17	30	26	15.3
		Yemmigunur	3	5	10	19	29	21	14.5
		Mantralayam	5	6	11	19	36	29	17.7
	Average		4.75	6	10.75	18.5	33	27.5	14.8

IR – Infestation Ratio

4. CONCLUSION

Enhanced damage to the flowers (Rosette flowers) was observed in different surveyed sites in Andhra Pradesh. This may be predominantly due to the widespread cultivation of long-duration Bt cotton hybrids with different flowering and fruiting stages, extension of normal crop season through ratooning by providing supplementary irrigation and fertilizer application.

These unscientific practices will aid in the buildup of PBW in later crop growth stages and causes continuous damage to the flowers and bolls as the crop progresses and peaks at 120 DAS, resulting in severe loss of seed cotton. Though most economic damage was confined to later crop growth stages, the pest activity was observed from flowering and continued even after harvest. Hence, round the year, management measures have to be taken up. Awareness needs to be created on the off-season, pre-season, in-season and post-season practices for minimizing the damage and achieving maximum yields with minimum damage to the ecosystem.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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