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Incidence of Pink bollworm *Pectinophora gossypiella* (Saunders) in *Bt* cotton in different agro ecological zones of Andhra Pradesh, India

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ABSTRACT

Pink bollworm has emerged as a major threat for successful cotton cultivation in Andhra Pradesh, extensive random roving survey was conducted in three major cotton growing districts of Kurnool, Guntur and Krishna during 2021 and 2022 seasons to assess the dynamics of pink bollworm infestation. During the year 2021 rosette flower incidence, green boll, open boll and locule damage ranged from 1.8-6.8, 16.6-31.6, 14.9-53.1 and 13.4- 28.4 respectively. During 2022 rosette flower incidence, green boll, open boll and locule damage ranged from 1.8-8.0, 19.3-31.5, 34.5-59.4 and 14.3-32.8 respectively. Gradual progression of pink bollworm infestation was noticed with the advancement of crop season.

***Key words**: Pink bollworm, Rosette flower, Green boll damage, Open boll damage, Locule damage.*

Introduction

Cotton (*Gossypium hirsutum* L.) is a major commercial crop in India and Andhra Pradesh. 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 (AICCIP 2020 annual report). Of the several factors contributing to the low yield of cotton, biotic constraints are important, of which the insect pests play a crucial role. In this, the pink bollworm *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) has recently emerged as a major threat to cotton production in India. The insect is native to the Indo-Pak region (Saunders WW) 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 (CABI). PBW larvae feed on cotton flowers, buds, bolls, and seeds, causing malformed flowers known as rosette flowers, premature opening and heavy shedding of infested bolls, de-

creased fiber length, and poor lint quality due to staining (Singh JP). 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 [Patil SB]. 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 ecosystem, resulting in bollworm exacerbation and secondary pest problems. 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 (Shrilakshmi and Udikeri, 2021), targeting the dreaded bollworm complex, which included the American bollworm *Helicoverpa armigera* (Hub.), spotted bollworm *Earias vitella* (Fab.) and pink bollowm. Until 2009, *Bt* cotton technology performed well and offered promising boll-worm complex control. As a result, Pink bollworm 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. Even after the introduction of *Bt*-cotton in India, Pink bollworm (PBW) showed multifold resistance to Bollgard I event (Cry1Ac) in Gujarat during 2010 with a resistance ratio of 44 (Dhurua and Gujar, 2011) and subsequently to Bollgard II (Cry1Ac + Cry2Ab) with 40-80 per cent of the bolls harboured surviving larvae as recorded from Amreli and Bhavnagar districts of Gujarat during 2014 From 2014 onwards, reports have highlighted the outbreak of pink bollworm on Bollgard I and Bollgard II in states namely, Gujarat, Madhya Pradesh, Maharashtra, Karnataka, and Andhra Pradesh with a resistance ratio of 1387 to Cry1Ac and 4196 to Cry2Ab in 2017 from central and southern India (Naik *et al.,* 2018).

Under the circumstances, the present investigation aims we aimed at documenting widespread field level infestation of PBW in *Bt* cotton from different agro ecological zones of Andhra Pradesh.

Materials and Methods

A survey was conducted to assess the intensity of pink bollworm in major cotton growing districts of Kurnool, Guntur and Krishna districts during the years 2021 & 2022. Extensive random roving surveys were conducted to record the flower damage (rosette flower), green boll damage, open boll damage and locule damage during different phenophase of cotton crop, at 45, 90, 110 and 130 DAS. In each district three mandals were selected in each mandal three villages were be covered in each village five farmers were covered with a total of 45 farmers covered in each district, the incidence of pink bollworm was recorded in random roving survey method. Rosette flower incidence was recorded at 45 DAS by collecting 50 flowers randomly in one acre of field and observes for rosette flowers. Green boll damage was recorded at 90 DAS by collecting 20 green bolls randomly from one acre of field and recording the pink bollworm incidence through destructive sampling during the last week of October. Open boll damage was recorded at 110 and 130 DAS during November and December months, locule damage was recorded at harvest. Pink bollworm larvae per 20 green bolls/acre was also recorded at 90 and 110 DAS. Data was collected on percentage rosette flower incidence, green boll damage, open boll damage, locule damge and pink bollworm larvae per twenty green bolls.

Results

Survey

The survey on pink bollworm incidence during different crop growth stages were recorded in Kurnool, Guntur and Krishna districts during 2021 and 2022. The results on rosette flower incidence, green boll damage at 90 DAS, open boll damage at 110 and 130 DAS, locule damage and pink bollworm larvae/20 green bolls were tabulated in table No 1& 2

Rosette flower incidence

During 2021 among the three districts surveyed mean rosette flower incidence of 6.2% was recorded at 45 DAS in Guntur district, the next highest incidence of 2.8% was recorded in Kurnool district closely followed by Krishna district which recorded an incidence of 2.1%. Overall trend on rosette flower incidence reflects that incidence at 45 DAS is lower and below ETL in all the districts surveyed during the year 2021.

Green boll damage at 90 DAS and open boll damage at 110 and 130 DAS

Highest mean green boll damage of 28.5% was recorded in Kurnool district followed by Guntur and Krishna districts which recorded a damage of 21.4 and 18.6% respectively. Highest open boll damage of 35.9% was recorded in Kurnool district followed by Guntur district which recorded a damage of 19.5% and Krishna district which recorded 6.9% at 110 DAS, at 130 DAS, Kurnool district had recorded highest open boll damage of 42.3 followed by Guntur and Krishna districts which recorded a damage of 28.2 and 17.1% respectively. From the above trend on boll damage due to pink bollworm and data obtained it is evident that Kurnool district is the major vulnerable region for pink bollworm damage which starts at 90 DAS and gradually progress along with the crop growth.

Locule damage and pink bollworm larval recovery at 90 and 110 DAS

Highest locule damage of 25.6% was recorded in Kurnool district during last picking followed by Guntur and Krishna districts which recorded a damage of 19.4 and 15.9% respectively. Highest mean pink bollworm larval recovery of 6.3 per twenty green bolls were recorded in Kurnool district followed by Guntur and Krishna districts which recorded a larval recovery of 2.0 and 1.0 per twenty green bolls respectively at 90 DAS.

At 110 DAS highest pink bollworm larval recovery of 14 per twenty green bolls were recorded in Kurnool district followed by Guntur and Krishna districts which recorded a larval recovery of 4.3 and 3.3/twenty green bolls respectively. From the data obtained from the three districts on locule damage and pink bollworm larval recovery it is evident that Kurnool district is the most vulnerable region for pink boll worm incidence among the districts surveyed (Table 1).

During 2022

Highest rosette flower incidence of 6.5% was recorded in Guntur district followed by Kurnool and

Table 1. Survey of pink bollworm incidence in major *Bt* cotton growing districts of Andhra Pradesh
Mean rosette flower incidence, green boll, open boll , locule damage and pink bollworm larvae recovery during 2021 in Kurnool, Guntur and Krishna districts of Andhra Pradesh.

S. No	District	Mandals	% Rosette flower incidence at 45 DAS	% green boll damage at 90 DAS	% Open boll damage at 110 DAS	% Open boll damage at 130 DAS	% Locule damage at final picking	Pink bollworm larval recovery at 90 DAS from 20 green bolls	Pink bollworm larval recovery at 110 DAS from 20 green bolls
1	Guntur	Tadikonda	6.2	23.3	20.9	30.4	14.3	3	4
		Amaravati	6.8	18.0	18.0	26.9	24.3	2	6
		Tullur	5.6	23.0	19.7	27.5	19.7	1	3
	Mean		**6.2**	**21.4**	**19.5**	**28.2**	**19.4**	**2**	**4.3**
2	Kurnool	Gadivemula	3.6	31.6	32.3	41.1	28.4	5	12
		Orvakal	3.0	25.0	24.4	32.7	20.8	8	14
		Gudur	2.0	29.0	51.1	53.16	27.8	6	16
	Mean		**2.8**	**28.5**	**35.9**	**42.3**	**25.6**	**6.3**	**14**
3	Krishna	Ibrahimpatnam	2.1	22.3	6.2	15.3	14.9	2	5
		Kanchikacharla	2.6	17.0	10.5	21.3	19.6	1	2
		Nandigama	1.8	16.6	4.1	14.9	13.4	0	3
	Mean		**2.1**	**18.6**	**6.9**	**17.1**	**15.9**	**1.0**	**3.3**

Krishna districts which recorded 4.0 and 2.1% of incidence at 45 DAS. Highest green boll damage of 30.3% was recorded in Kurnool district which is followed by Krishna and Guntur districts which recorded 23.7 and 22.6% respectively at 90 DAS. Highest open boll damage of 39.3% was recorded in Kurnool district followed by Guntur and Krishna districts which recorded 21.5 and 11.2 percent respectively at 110 DAS, similarly at 130 DAS highest open boll damage of 51.5 was recorded in Kurnool district followed by Guntur and Krishna districts which recorded 43.9 and 38.0% respectively.

Highest locule damage of 27.1% was recorded in Kurnool district followed by Krishna and Guntur districts which recorded 19.6 and 19.4% respectively. Highest mean pink bollworm larval recovery of 9.0 per twenty green bolls were recorded in Kurnool district followed by Guntur and Krishna districts which recorded 7 and 3.3 per twenty green bolls respectively at 90 DAS. At 110 DAS highest mean larval recovery of 14.3 per twenty green bolls was recorded in Kurnool district which was followed by Guntur and Krishna districts which recorded a recovery of 9.0 and 6.0 per twenty green bolls respectively (Table 2).

Discussion

These results stand in the persuasion of Muttappa and Patil 2019 who recorded the rosette flowers were ranged from 2.25 to 15.45 % with seasonal mean of 9.05 %. Similarly, Rathod (2016) also observed the highest pink bollworm larval population 7.33/10 green bolls during first week of November. The present studies on survey are in corroboration with Rhakesh *et al*., 2023 who reported in their roving survey that roving survey of PBW on cotton bolls indicated a progressive increase in the larval incidence and green boll damage from October to February. The present results which depict varying degree of pink bollworm infestation differing spatial-Temporally in different zones of Andhra Pradesh are in clear collaboration with the findings of Shrilakshmi *et al*. (2021) Who also reported in their survey during 2018 that typical pattern of progressive increase in the level of pink bollworm infestation and intensification of locular damage with the advancement of the crop season was evident, further they reported that in Karnataka least percent of flower damage recorded from Uttara Kannada, i.e. 1.48%, 0.97% in 2017-18 and 2018-19 respectively, followed by Shivamogga and Chitradurga. Least locule damage was recorded from Uttara Kannada during both the years (19.96%, 12.89%), followed by Shivamogga (35.45%, 30.22%) and Chitradurga (38.50%, 30.72%).

Table 2. Mean rosette flower incidence, green boll, open boll, locule damage and pink bollworm larvae recovery during 2022 in Kurnool, Guntur and Krishna districts of Andhra Pradesh.

S. No	District	Mandals	% Rosette flower incidence at 45 DAS	% green boll damage at 90 DAS	% Open boll damage at 110 DAS	% Open boll damage at 130 DAS	% Locule damage at final picking	Pink bollworm larval recovery at 90 DAS from 20 green bolls	Pink bollworm larval recovery at 110 DAS from 20 green bolls
1	Guntur	Tadikonda	7.0	22.6	23.7	55.2	14.3	7	9
		Amaravati	8.0	22.0	19.6	36.1	24.3	6	8
		Tullur	4.6	23.3	21.2	40.4	19.7	8	10
	Mean		6.5	22.6	21.5	43.9	19.4	7	9
2	Kurnool	Gadivemula	5.7	31.5	35.7	60.7	32.8	9	13
		Orvakal	3.0	24.3	30.4	34.5	20.8	11	16
		Gudur	3.3	35.3	52.0	59.4	27.8	7	14
	Mean		4.0	30.3	39.3	51.5	27.1	9	14.3
3	Krishna	Ibrahimpatnam	2.1	22.3	11.6	38.6	19.6	4	6
		Kanchikacharla	2.6	29.6	13.5	38.0	19.6	3	5
		Nandigama	1.8	19.3	8.7	37.6	19.7	3	6
	Mean		2.1	23.7	11.2	38.0	19.6	3.3	6

Conclusion

This field study indicated that the damage to Bt. cotton plants was very high presently across Andhra Pradesh particularly in Kurnool district among the three districts surveyed. The failure of *Bt* cotton in reducing PBW populations, and the near absence of other bollworm species, has, perhaps, created a vacant niche for the PBW, thus allowing it to build pestiferous populations. Over reliance and wide spread cultivation of *Bt* genotypes over many years has created lot of selection pressure on PBW, thus leading to resistance development. Besides, PBW do not have an alternate/ alternative host in practical sense. Poor compliance of refugia is also said to synergise the resistance development of PBW against Cry toxins. Presently no much chemical control means are significant. Therefore, it is suggested that integrated pest management practices would be ideal in PBW management. There exists very few published reports documenting PBW resistance to first generation Bt cotton, i.e. Bollgard carrying single gene Cry1Ac in India. One cannot neglect the very possibility that the pest that had broken out seriously in one part of the country may also pose severe threat to the other parts in due course of time causing havoc. Therefore, we feel this is the right time to alert the stakeholders of cotton production on the seriousness of the issue and to devise strategies and policies appropriate for the effective and ecofriendly management of this serious pest of cotton. In this perspective we presented, through extensive surveying and repetitive sampling at various growth stages of cotton crop, a detailed picture of PBW infestation levels in various zones of Andhra Pradesh. The knowledge generated in present study will be crucial in getting deeper insights into the dimensions of PBW infestations that may help in assessing the potential yield losses in cotton crop.

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 offseason, pre-season, in-season and post-season practices for minimizing the damage and achieving maximum yields with minimum damage to the ecosystem.

Conflict of Interest- None

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