“MANAGEMENT OF PINK BOLLWORM (*Pectinophora gossypiella* Saunders) IN *Bt* COTTON”

by

Mr. Pathan Yasinkha Kausarkha
(Reg. No. 019/154)

A Thesis submitted to the

**MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI-413 722, DIST. AHMEDNAGAR,
MAHARASHTRA, INDIA**

In partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL ENTOMOLOGY

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY

POST GRADUATE INSTITUTE

**MAHATMA PHULE KRISHI VIDYAPEETH,
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2021

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
there of has not been submitted
by me or other person to any
other University or Institute
for a Degree or
Diploma.

Place : MPKV, Rahuri

Date : / /2021

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This is to certify that the thesis entitled, **"MANAGEMENT OF PINK BOLLWORM (*Pectinophora gossypiella* Saunders) IN *Bt* COTTON"** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (MAHARASHTRA) in partial fulfilment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ENTOMOLOGY**, embodies the results of a piece of bonafide research work carried out by **Mr. PATHAN YASINKHA KAUSARKHA** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

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Place: MPKV, Rahuri **(P.N. Rasal)**

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ACKNOWLEDGEMENT

Even a small achievement remains mere event till the helping hands behind that never get remembered. I don't want to miss this opportunity to thanks all those who have directly or indirectly helped me for successful completion of this work.

It was a really great pleasure and privilege for me to work under the guidance of Dr. N. K. Bhute, Assistant Entomologist, Cotton Improvement Project, MPKV, Rahuri. I humbly express my profound gratitude for his indomitable quest for science, systemic and inspiring guidance, constructive criticism, unceasing interest, generous help, patient audience, amiable dealing and transcendent suggestions to complete the tasks. I express my heartfelt gratitude to his teachings, dedicated efforts to profession, scientific view, time sense, sincerity, moral and values has inspired me to shape my career. I accord sincere thanks for his encouragement and guidance in my college life.

It is pleasure to expand my grateful thanks to the respected members of advisory committee, Dr. C. S. Patil, Head, Department of Agril. Entomology, MPKV, Rahuri; Dr. D. P. Pacharne, Associate Professor of Agronomy, Cotton Improvement Project, MPKV, Rahuri and Dr. S. T. Aghav Assistant Professor of Agril. Entomology, PGI, MPKV, Rahuri, for providing prompt guidance, constant inspiration, moral support and valuable help during the period of investigation.

I express my deep sense of honor to Dr. P. G. Patil Sir, Hon. Vice-Chancellor, MPKV, Rahuri, Dr. P. N. Rasal, Dean, Faculty of Agriculture and Associate Dean, Post Graduate Institute, MPKV, Rahuri and Dr. C. S. Patil, Head, Department of Agril. Entomology, MPKV, Rahuri, for giving permission and providing necessary facilities for the research work.

I also thankful to our esteemed teachers, Dr. R. V. Datkhile, Associate Professor, Department of Agril. Entomology, MPKV, Rahuri, Dr. P. R. Palande, Assistant Professor, Department of Agril. Entomology, MPKV, Rahuri, Dr. Y. S. Saindane, Assistant Residue Analyst, Department of Agril. Entomology, MPKV, Rahuri and Dr. S. A. Landge, Assistant Professor, Department of Agril. Entomology, MPKV, Rahuri for their constructive suggestions and advice during the course of studies. I extend my sincere thanks to Mr. Jafar Shaikh, Mr. Anand Rathod, Mr. Madhav Madane and Mr. Pritam and all other members of Cotton Improvement Project, MPKV, Rahuri for their coordinated help during my research schedule.

I take this opportunity to acknowledge the library of MPKV, Rahuri, for providing resourceful knowledge about my research work and various other objects.

I am extremely thankful to all my batchmates, Atul, Suraj, Vaibhav, Pravin, Sachin, Rahul, Anil, Sahil, Akash, Amit, Karan, Pawan, Pravin and Ashik for their excellent company, co- operation and help.

We felt in home always when we have friends around, my sincere thanks to my friends, Parvez, Mahendra, Dnyanu, Roshan, Rushabh, Gopal, Aslam, Ashish, Vishal, Prashant, Vaibhavraj, Rushi, Harshal, Sontakke, Suraj, Akshay, Chetan, Sagar, Shivnath, Aappya, Ambekar and whole NN-Series.

Today, here is smile on lips and light of hope in my eyes, because my fortune has changed for better. Behind this picture of prosperity lies the hard work, bondless love and sacrifice of my respectful father Mr. Kausarkha B. Pathan, mother Mrs. Sultanabi K. Pathan, grandfather Mr. Bholekha D. Pathan, grandmother Mrs. Jaybunabi B. Pathan; who educated me. Life would have remained a cipher space, if not the tremendous encouragement and genuine faith on me by brother Mr. Apsar K. Pathan, sister-in-law Mrs. Asamabi A. Pathan, brother Mr. Aslam K. Pathan, sister Shaheenbi R. Pathan, little angel of house pathan, my niece Mantasha, nephew Rehan and niece Bibi and the whole 'Pathan Family'. I am grateful to them.

I would like express my deep sense of gratitude and sincere thanks to my primary school teachers and teachers from Jr. college Risod. I express my cordial thanks to respected principal and Asstt. Professors of my UG College i.e. Vivekanand Agriculture College, Hiwara (Bk.),Tal. Mehkar, Dist. Buldana for valuable help in educational and life journey.

While traveling on this path of education, many hands pushed me forth; learned hearts put me on right track, enlightened by their knowledge and experience. I ever rest thanks to all of them. Last but not least I am grateful to each and everyone who directly and indirectly encourages me at every step of life.

Place : MPKV, Rahuri

Date : / /2021 **(Y.K. PATHAN)**

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LIST OF ABBREVIATIONS AND SYMBOLS

a.i.	:	Active Ingredient
AICCIP	:	All India Coordinated Cotton Improvement Project
BCR		Benefit Cost Ratio
Bt	:	*Bacillus thuringiensis*
CD	:	CriticalDifference
CICR	:	Central Institute for Cotton Research
cm	:	Centimetre (s)
cm^2	:	Square Centimetre
CS	:	Capsule Suspensions
CV	:	Coefficient of variation
DAS	:	Days after sowing
DAS	:	Days after spraying
EC	:	Emulsifiable concentrate
eg	:	Exempli gratia, For example
et al.	:	Et alia and others
etc	:	Etcetra
ETL	:	Economic Threshold Level
Fig.	:	Figure
gm	:	Gram (s)
GOB	:	Good open boll
ha	:	Hectare (s)
hr	:	Hour (s)
i.e.	:	That is (id est)
ICAR	:	Indian Council of Agricultural Research
ICBR	:	Incremental Cost Benefit Ratio
IPM	:	Integrated pest management
kg	:	Kilogram (s)
LC	:	Lethal concentration
lit	:	Litre (s)
m	:	Meter
m^2	:	Square meter
Max.	:	Maximum
mg	:	Milligram (s)
Min.	:	Minimum
ml	:	Milliliter (s)

mm	:	Milli meter
MPKV	:	Mahatma Phule Krishi Vidyapeeth
MT	:	Metric tone (s)
No./no.	:	Number (s)
NS	:	Non-significant
NSKE	:	Neem seed kernel extract
PBW	:	Pink bollworm
pp	:	Pages
ppm	:	parts per million
q	:	Quintal (s)
RBD	:	Randomized Block Design
RH	:	Relative Humidity
ROC	:	Reduction over control
Rs	:	Rupees
SC	:	Suspension concentrate
SE	:	Standard Error
Sig.	:	Significance
SMW	:	Standard Meteorological Week
SP	:	Soluble Powder
spp	:	Specie (s)
T	:	Tonne (s)
Temp.	:	Temperature
Viz.,	:	Videlicet (Namely)
w/w	:	Weight by weight
WSG	:	Water Soluble Granule
%	:	Per cent
˚C	:	Degree celcius
@	:	at the rate
/	:	Per
+,-	:	Plus, minus

ABSTRACT

"MANAGEMENT OF PINK BOLLWORM (*Pectinophora gossypiella* Saunders) IN *Bt* COTTON"

by

Mr. PATHAN YASINKHA KAUSARKHA

A candidate for the degree of

MASTER OF SCIENCE (AGRICULTURE)
In

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
2021

Research Guide : Dr. N. K. BHUTE

Department : Agricultural Entomology

The present study entitled, "Management of pink bollworm (*Pectinophora gossypiella* Saunders) in *Bt* cotton" was carried out at, AICCIP, MPKV, Rahuri-413 722 during *kharif*-2020. An investigation was undertaken with an objective of seasonal incidence of pink bollworm on *Bt* cotton, evaluation of different insecticides against pink bollworm in *Bt* cotton and evaluation of solar light trap against pink bollworm. The results revealed that the pheromone trap catches ranged from 1 to 350 moths/week with highest catches in 47^{th} SMW. The rosette flowers were ranged from 2.33 to 32.35 % while the green boll damage ranged from 1.11 to 43.24 %. The larval incidence of pink bollworm ranged from 0.26 to 38.12 per twenty bolls. Moreover, open boll damage and locule damage ranged from 40.12 to 48.12 % and 21.28 to 29.12 %. The pink bollworm incidence was negatively correlated with weather parameters.

Among the tested insecticides chlorantraniliprole 18.5 SC was found effective agains pink bollworm, recording lowest rosette flower (7.44%), green boll damage (8.78%), pink bollworm larvae (3.09/20 bolls). At harvest, chlorantraniliprole 18.5 SC recorded less open boll damage (7.26 %) and locule damage (4.09 %). For all the recorded observations spinetoram 11.7 SC and lambda cyhalothrin 5 EC were found at par with chlorantraniliprole 18.5 SC. Whereas cypermethrin 25 EC was found least effective in management of pink bollworm. Among tested insecticides chlorantraniliprole 18.5 SC produced highest yield of seed cotton (20.45 q/ha) which was found at par with spinetoram 11.7 SC (19.11 q/ha) and lambda cyhalothrin 5 EC (17.73 q/ha). Among different tested insecticides the highest ICBR *i.e.* 1:19.25 was registered in spinetoram 11.7 SC followed by lambda cyhalothrin 5 EC (1:17.98), chlorantraniliprole 18.5 SC (1:12.28) and indoxacarb 15.8 EC (1:11.63). Lowest ICBR was observed in cypermethrin 25 EC (1:3.75).

Light trap play an important role in field sampling, monitoring, capturing, killing and biodiversity studies of nocturnal insect population. Solar light trap was used in cotton field during *Kharif* 2020 against pink bollworm. Studies on light trap assessed by daily night collection. Results indicated that the adult trap catch of pink bollworm started from 38th meteorological week and its ranged from 4.85 to 140.57 moths per night. The adult trap catch of pink bollworm increased gradually to its first peak with highest trap catch in the last week of November (47th SMW) (140.57 moths per night) and thereafter gradually decreased till the last week of December.

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1. INTRODUCTION

Cotton (*Gossypium*) is a key fiber crop grown in more than seventy nations in the world, which perform essential role in the world's economic, political and social concerns. Cotton belongs to Malvaceae family and the genus *Gossypium*. As a commercial commodity, it plays a important part in industrial activities of the nation, both in terms of job creation and foreign exchange, hence it is popularly known as “White Gold” and “Friendly Fiber”.

Global 2019-20 cotton area, production and productivity were 34.50 million hectares (85.50 million acres), 121 million bales and 791 kg/ha, respectively (Anonymous, 2020a). India, China, United States and Brazil together, they account for 74 per cent of global cotton production. India occupies 37.56 per cent of world cotton area and produces 24.26 per cent of world cotton production and stands tall. The second largest producer of cotton-China, occupies 9.97 per cent of world cotton area and produces 22.41 per cent of world cotton production. In India during 2019-2020 the area, production and productivity of cotton were 125.84 lakh hectares, 360 lakh bales of 170 kg and 486 kg lint/ha, respectively (Anonymous, 2020b).

India earns foreign exchange to the tune of 12-14 billion dollar annually from exports of cotton yarn, thread, textiles and apparels. It supports the cotton textile business in the country, which is the country's largest organized industry component. Millions of people in the country are employed in cotton farming, trading, processing, manufacturing, fabricating and marketing 13.5 million bales of 170 kg. India's domestic and international trade is projected to be worth (Rs. 15,000 crores) 30 US billion dollars every year (Anonymous, 2015). Sixty million people work in the agricultural and industrial sectors of cotton production, processing, textiles and allied industries, either directly or indirectly. Cotton exports generate around Rs 76,000 crores in foreign exchange earnings, accounting for one-third of our country's overall foreign exchange earnings (Anonymous, 2007).

In India major cotton growing states are Maharashtra, Gujarat, Madhya Pradesh from central zone, Telangana, Andhra Pradesh, Karnataka and Tamil Nadu from south zone and Punjab, Haryana, Rajasthan from north zone. In Maharashtra during 2019- 2020 the area, production and productivity of cotton were 43.69 lakh hectares, 82.00 lakh bales of 170 kg and 319 kg lint/ha, respectively (Anonymous, 2020b).

Though there are several reasons that attributed to low yield, pest losses play a major role because cotton is paradise for an insect. Globally a total of 1326 insect's species have been recorded on cotton (Hargreaves, 1948). In India, some 130 distinct species of insects and mites have been recorded to harm cotton crops (Agarwal *et al*., 1984). Cotton's pest spectrum is highly diverse, encompassing a variety of insect species. Aphids (*Aphis gossypii* Glover), jassids (*Amrasca biguttula biguttula* Ishida), thrips (*Thrips tabaci* Hood) and whitefly (*Bemisia tabaci* Gennadius) are sucking pests that have reached epidemic proportions. However, the bollworm complex, which includes the American bollworm (*Helicoverpa armigera* Hub), spotted bollworm (*Earias vitella* Fab) and pink bollworm (*Pectinophora gossypiella* Saunders), is responsible for a 36.2 per cent yield loss (Kranthi *et al*., 2005).

Pink bollworm *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechidae) is a major cotton pest that burrows into cotton bolls to feed on the seed. Saunders (1843) described the pink bollworm *Pectinophora gossypiella* (Saunders) as *Depressaria gossypiella* from specimens found infecting cotton in India in 1842 (Ingram, 1994). Eggs are laid in sheltered parts of the plant, such as the axis of petioles or peduncles, the underside of new leaves and on buds or flowers, early in the season. When the bolls are 15 days old, these become the preferred oviposition locations for adults. The first two larval instars are white but the 3^{rd} and 4^{th} instar are pink.

The lint of pink bollworm- affected bolls develops a pink tint and is of poor quality. Other insects and fungus can enter the boll and cause additional harm as a result of the feeding damage. When the cotton bolls quits by the larvae of pink bollworm, it leaves a perfectly round and clean cut exit hole, indicating that the boll has been damaged by the pink bollworm (Sarwar, 2017).

Pink bollworm damages locules to the tune of 55 per cent, with seed cotton yields ranging from 35 to 90 per cent. The country lost 6525 metric tonnes of lint worth Rs 1216 million as a result of this pest (Agarwal and Katiyar, 1979) and 2.81 to 61.87 per cent reduction in seed cotton yield, 3.44 to 37.83 per cent loss in germination, 2.12 to 47.13 per cent loss in oil content and 10.66 to 59.15 per cent loss in normal boll opening under unprotected conditions (Patil, 2003).

Genetically modified cotton is developed to be resistant for the lepidopteran target pests, *viz*., *H. armigera, P. gossypiella, H. virescens* (Fabricus) and *Earias* spp. These cotton contains *Bt*, a gene toxic to target pests. The performance of *Bt* cotton against bollworms has been outstanding (Nadaf and Goud, 2007). The limited release of three Mahyco- Monsanto transgenic *Bt* hybrids, MECH-12, MECH-162 and MECH-184 for commercial cultivation by the Government of India on March 26, 2002 has ushered in a new era in production of cotton in India (James, 2002). Since then, India has grown *Bt* cotton from 50,000 hectares during 2002 to almost 11.6 million hectares in 2014 (Anonymous, 2014). *Bt* cotton was certified for commercial cultivation in India in 2002. In the first year, *Bt* cotton provided outstanding lepidopterous pest control. However, pink bollworm infestations on *Bt* cotton were first observed in Gujarat in 2008 on the BG-I hybrid and afterwards on the BG-II.

With a vengeance, the pink bollworm has returned. About 30 years ago, this insect constituted a severe threat to cotton in India. Since 1982, there have been very few reports of pink bollworm damage to cotton in the country. But that's all changed now. Pink bollworm damage to bolls and yield losses in *Bt* cotton were seen this year in numerous sections of Gujarat, as well as areas of Andhra Pradesh, Telangana and Maharashtra. Worse yet, the worm is happily chewing up Bollgard-II-Bt cotton, which has two genes (cry 1Ac + cry 2Ab) that were meant to be particularly efficient in pest management. The pink bollworm gained tolerance to two cry poisons used in Bollgard-II, according to studies done by ICAR-CICR (Central Institute for Cotton Research, Nagpur) over the last two years. BG-II pink bollworm larvae survival was much higher in 2012, 2013 and 2014, according to Monsanto, primarily in the Amreli and Bhavnagar districts of Saurashtra, Gujarat (Kranthi, 2015).

Insect attack on the crops and reduce the yield considerably. The yield loss due to insect can be minimized by using insecticides. But there is major problem of residue of insecticide, persist for long period. Those insecticide residues enter the food chain of human beings and prove to be quite toxic to them. As a result, the use of non-chemical techniques in IPM against crop insect pests is of particular importance in reducing the usage of hazardous chemicals. Use of light trap is one of such approaches.

Light traps are simple interception devices that attract and capture insects travelling through an area and are used for broad insect diversity surveys. Light trap have became commonly used in techniques like Integrated Pest Management in several areas of the world when the concepts of Integrated Pest Management and Economic Threshold were introduced in 1975, as well as the resurgence of non-chemical pest control approaches. There was a sense of urgency to employ a non-chemical pest control strategy that was both commercially viable and environmentally safe. The use of light traps is one method of pest management that does not require the use of insecticides (Vaishampayan and Vaishampayan, 2016).

Because it traps both the sexes of insect pests and significantly reduces carryover pest populations, the light trap is most effective tools of insect pest management. Seasonal patterns of insect density in cropped regions are also determined using light traps. It also gives information on insect distribution, abundance, flight patterns and helps to decide the timing of the spraying.

Control of the pink bollworm by insecticide is difficult unless precise timing of application is obtained. Because stages of the larvae found within the bolls are well protected by the developing bolls. In this context, pheromones play significant role in the pink bollworm management in a variety of ways. Prediction of pink bollworm can only be achieved by integrating pheromones for monitoring the incidence of pink bollworm by using adult catch in traps, allowing for the perfect control measure to be initiated and early spraying to be reduced. Pheromones also play a key role in mass trapping and mating disruption of pink bollworm adults at the field level, reducing infestation to a minimum levels or integrating with least plant protection measures. Pheromones are also eco-friendly in nature, benefiting farmers by reducing their investment in more sprays while having no negative effects on beneficial insects.

To overcome the losses and to increase the yield, pesticides application is the most important. It is important to compare the efficacy of insecticides against pests for effective pest management and to reduce the indiscriminate use of insecticides. With regard to this, present investigation on pink bollworm was carried out with following objectives.

Objectives

1. To study seasonal incidence of pink bollworm on *Bt* cotton.
2. To evaluate different insecticides against pink bollworm in *Bt* cotton.
3. To evaluate solar light trap against pink bollworm.

2. REVIEW OF LITERATURE

A thorough assessment of the literature is a necessary component of any scientific investigation. The review of literature pertaining to seasonal incidence, evaluation of insecticides against pink bollworm and evaluation of solar light trap against pink bollworm in cotton are presented below.

2.1 Seasonal Incidence of Pink Bollworm on *Bt* Cotton

Pink bollworm has become an important cotton pest in India, inflicting significant economic losses by destroying buds, flowers, and bolls during later stages of the crop. Seeds, on the other hand, are the primary food source. Cotton has a wide variety of planting dates, ensuring a constant food supply throughout the year, which aids the pest's proliferation. The severity of the damage and the peak period of occurrence differ from year to year due to seasonal variations. One of the conditions for designing successful and cost-effective tactics is information on the presence of a pest in relation to different seasons.

2.1.1 Pheromone Trap Catches

Dhawan and Sidhu (1984) observed that under Punjab conditions PBW moth emergence started during first fortnight of March and peaked emergence in the first week of October.

Cividanes (1989) revealed that adult males were captured using pheromone traps that were emptied every two weeks and larvae were counted in weekly samples of cotton bolls. April, May, June, October and November were the months with the highest population. Larvae were found in cotton bolls from the 77th day after plant emergence.

Singh and Lather (1989) reported that the adult emergence of the pink bollworm from the short cycle brood began in Haryana in mid July and lasted until the first week of November.

Gupta *et al.* (1990) observed peak population of adult males from the second fortnight of August to the first week of November and peak larval incidence from the second week of October to the second week of December.

Michel (1992) investigated the population dynamics of *P. gossypiella* in cotton field using pheromone traps. Although a few adults were present throughout the year, the main flight periods were October- November and March- April, which corresponded to the dates when cotton was sown and end of the crop cycle, respectively.

Gupta *et al.* (1996) stated that the emergence of pink bollworm started in November and the emergence was highest in second week of December.

Korat and Lingappa (1996) revealed that pink bollworm moth emergence began in the second week of October and there was a positive and substantial link between trap captures and larval population. Trap catches and field infestation were found to have a similar positive and significant relationship.

Naik *et al.* (1996) studied seasonal activity of pink bollworm, *P. gossypiella* and reported that the pest was active on cotton throughout the year with the peak activity occurring from the third week of October to the second week of December.

Gopalaswamy *et al.* (2001) revealed that the progressive build up of pink bollworm starts from November with a peak level of pest activity from February to the beginning of April.

Tomar and Tomar (2005) reported that pink bollworm activity was reported from October to December.

Radhika and Reddy (2006) revealed that the PBW activity had progressed to as early as August (2004- 2005). The peak activity of pest, consistently high during end of the season.

Sandhya Rani *et al.* (2010) studied the seasonal progression and incidence of *P. gossypiella* on cotton. The data on adult trap catches revealed that the incidence of pink bollworm began in September and grew steadily till the second week of November, corresponding to the 45th SMW (8.2 moths/ trap), after which there was a gradual increase in adult trap catches from the third week of November, corresponding to the 46th SMW (26.44 moths/ trap) to the second week of December, corresponding to the 46th SMW (26.44 moths/ trap).

De Melo *et al*. (2012) observed that the first peak of *P. gossypiella* males capture occurred approximately 80 days after cotton emergence, which was possibly due to stage of plant development (*i.e.*, early flowering). The highest population peak were observed 140-170 days after cotton emergence,

Kumar *et al.* (2012) monitored the activity of pink bollworm moth through sex pheromone traps. They reported that the peak collections of Pink bollworm were seen in 50th SMW.

Ramesh Babu and Meghwal (2014) reported that the peaks of moth populations of pink bollworm were recorded during the 41-52nd SMW corresponding to the larval population in the field. During 2011, the number of male moth catches of pink bollworm was predicted at 84 per cent. They also reported a comparable larval population of pink bollworm in *Bt* cotton.

Khuhro *et al*. (2015) studied for five years, from 2009 to 2013, the male moth activity of *P. gossypiella*. Every year male moths began to trap from January to March and then disappeared from April to July. Its trap catches began again in August and lasted until December. Every year, the moth trap population fluctuated. During the month of October 2013, the highest moth captures (7.67/trap) were observed. In all years the maximum moths were catched in the month of October.

Sharma *et al.* (2015) studied that the peak pink bollworm pheromone catches were recorded during 42nd SMW.

Ali *et al.* (2016) observed the impact of weather factors on the population dynamics of pink bollworm for three consecutive years from 2009 to 2011 at the Entomological Research Sub-station, Multan using pheromone traps. They found that during the year 2009 and 2011, the highest peaks of pink bollworm appeared in the month April, with 1.1 and 1.13 moths/trap at 37.78 and 36.78 ˚C (maximum temperature), 22.00 and 20.12 ˚C (minimum temperature), 29.89 and 28.46 ˚C (average temperature), and 67 per cent (relative humidity), respectively, whereas peak appeared in November and December in 2010.

2.1.2 Seasonal Incidence of Pink Bollworm on *Bt* Cotton

Jha and Bisen (1995) indicated that pink bollworm incidence in cotton flowers was observed from August to September and in bolls from September to October. They also observed that pest incidence was also high in crops sown in April and May compared to late-sown crops in June.

Sangareddy and Patil (1997) reported that the occurrence of pink bollworm larvae began in October and gradually increased and reached to peak in February and decline thereafter.

Khan *et al.* (2002) found high level of pink bollworm infestation during October, when temperatures range from 28.31 ˚C to 30.08 ˚C and relative humidity ranges from 46.91 to 53.50 per cent and there was no rainfall during October.

Patil (2003) revealed that pink bollworm incidence was lowest (32.28 %) on early sown crop (June 10th) and highest (64.94 %) on late sown crop (August 25th). From December onwards, the incidence became more severe (above 50 %). Furthermore, there was a higher infestation of pink bollworm population in non-*Bt* cotton in the months of January and February (DCH-32).

Srinivasa Rao (2004) recorded the larval incidence of pink bollworm from first week of January in *Bt* cotton hybrids, while it began in hybrid Bunny in the month of December with peak larval activity at the end of February.

Nadaf and Goud (2007) studied the population dynamics of pink bollworm in *Bt*-cotton and non-*Bt* hybrids (RCH-2 *Bt* and RCH-2 non-*Bt*). Irrespective of *Bt* and non-*Bt* cotton, the rosette flowers were observed from the third week of September onwards, which peaked in 45th SMW. The quantity of rosette flowers gradually decreased over time. When compared to non-*Bt* cotton the average percentage of rosette blooms in *Bt* cotton was much lower (3.0 %). In comparison to non-*Bt* cotton hybrids, *Bt* cotton hybrids had a much lower number of pink bollworm larvae. During the peak boll development period, 13.7 and 40.6 per cent green boll damage was registered in *Bt* and non-*Bt* cotton, respectively. Irrespective of *Bt* and non-*Bt* cotton the number of exit holes were higher at harvesting stage (February). Significantly, lower number of exit holes were observed on *Bt* cotton compared to non-*Bt* cotton hybrids.

Venilla *et al.* (2007) studied seasonal abundance of pink bollworm for five years and reported maximum population during 27th week of crop emergence in 2001, while comparatively lower population was observed in subsequent years.

Patil (2011) recorded that the seasonal incidence of pink bollworm on open boll was 22.97 per cent damage during cropping period.

Laxman *et al.* (2014) recorded the infestation of pink bollworm in *Bt*-cotton and non *Bt*-cotton in September (12th week of crop). The mean percentage of infestation was maximum in October (19th week) in *Bt* (5.33 ± 0.55) and non *Bt*-cotton (6.52 ± 1.59) during 2010-2011 cropping season. During 2011-2012, its infestation was recorded in 16th week of crop in *Bt*-cotton and 13th week in non *Bt*-cotton. Maximum percentage of infestation was recorded in October (19th week).

Arshad *et al*. (2015) reported that maximum numbers of rosette flowers were observed on 30th July and 20th August in unsprayed non-*Bt* cotton, however, very few or no rosette flowers were observed in *Bt* cotton with and without spray. Whereas, larval number increased in *Bt* cotton with and without spray in September and October but remained below the economic threshold. The larval density was maximum in unsprayed non-*Bt* cotton (1.98/ 25 bolls) than unsprayed *Bt* cotton (0.46 larva/ 25 boll).

Somaa (2016) noticed the effect of certain weather factors on the population density of the pink bollworm during two successive seasons 2014 and 2015 at Giza in Egypt and found that the initial occurrence of the pink bollworm larvae on cotton bolls was recorded in the last week of July (26th) during the first season and week early (18th of July) during the second season and exhibited four peaks of population density in every season.

Rawal *et al*. (2017) reported that irrespective of *Bt* and non-*Bt* genotypes the bollworms infestation in squares started from 30th SMW and it increased continuously and reached to its peak during 39th SMW (4th week of September) (9.29 per cent), after that decreased and on 41st SMW, it was recorded 7.37 per cent. Bollworms infestation varied significantly among *Bt* and non-*Bt* genotypes throughout the period of observation, being significantly higher in non-*Bt* genotypes and lower in *Bt* genotypes.

Shinde *et al*. (2017) observed that the infestation of pink bollworm was initiated from 44th SMW with peak population of 0.6 larvae per plant during 47th SMW.

Verma *et al*. (2017) observed that the pink bollworm, *P. gossypiella* infestation on flowers found higher in 2nd week of September with intensity of 7 larvae per 30 flowers. While, peak larval population on bolls was recorded in 3rd week of September with intensity of 8 larvae per 30 bolls. Open boll damage was recorded 29.99 per cent, whereas open locule damage recorded 18.05 per cent.

Bhute *et al*. (2018) studied the seasonal incidence of bollworm complex on *Bt* cotton and influence of weather parameters on their incidence during *Kharif* during 2007-08. They found that incidence of pink bollworm started from 40th SMW (115 DAS) which was peak incidence *i.e*. 2 larvae/ 20 bolls.

Shinde *et al.* (2018) observed peak incidence of pink bollworm on green bolls during 46th SMW.

Yalawar and Patil (2019) observed incidence of pink bollworm, *P. gossypiella* on green bolls from first fortnight of September (34th SMW).

Divya *et al.* (2020a) observed that the incidence of pink bollworm was started during 32nd SMW and attended its severity at 46th SMW (15 larvae/ 20 bolls).

Sarode *et al*. (2020) studied the seasonal incidence of major insect pests and their correlation with weather parameters in cotton.

2.2 Evaluation of Different Insecticides against Pink Bollworm on *Bt* Cotton

Gupta *et al.* (1987) reported that, flucythrinate @ 50 gm a.i./ha, fenpropathrin @ 100 gm a.i./ha and deltamethrin @ 15 gm a.i./ha were found to be more effective than conventional insecticides in controlling pink bollworm and improving seed cotton production and lint quality.

Khurana and Varma (1991) reported that 4 to 5 sprays of flucythrinate, fenvalerate and cypermethrin @ 50 gm a.i./ha and decamethrin (deltamethrin) @ 25 gm a.i./ha against

Pectinophora gossypiella in cotton was effective as compared with 4 sprays of monocrotophos, fenthion, phenthoate and quinolphos @ 500 gm a.i./ha and carbaryl at 1.0 kg/ha. The synthetic pyrethroids outperformed the other forms of insecticides and flucythrinate produced the highest yields.

Mourad *et al.* (1991) evaluated 12 insecticides against pink bollworm and reported that lambda-cyhalothrin was the most efficient pyrethroid against pink bollworm, whereas fenvelarate was the least effective. The organophosphate insecticides, sulprofos and the carbamate, carbaryl were less effective than pyrethroids.

Ayad *et al.* (1993) investigated the insecticide sensitivity of *Pectinophora gossypiella* to field strains and it was found that pyrethroids were significantly more toxic to the pest than organophosphates and carbamates. Cyfluthrin, fenpropathrin, alpha-methrin, deltamethrin, fenvalerate, cypermethrin, cyanophos, methomyl, profenofos, methamidofos, chlorpyriphos and thiodicarb were listed in descending order of toxicity.

Afzal *et al*. (1998) studied the comparative efficacy of the insecticides diafenthiuron + cypermethrin, cypermethrin + profenofos, lambda cyhalothrin, cyfluthrin + methamidophos and decarafluron through three different sprays were evaluated against the bollworm complex (American bollworm, spotted bollworm and pink bollworm of cotton. All the insecticidal spray schedules were effective against the bollworm complex; although one with three consecutive sprays of cypermethrin + profenofos was the most effective.

Brickle *et al*. (1999) evaluated the effectiveness of six different insecticides against cotton bollworms in transgenic *Bt* cotton. Lambda cyhalothrin was found to be particularly effective at lowest rates among these pesticides.

Gopalaswamy *et al.* (2000) stated that, three novel insecticides, beta-cyfluthrin (24.11 per cent), spinosad (25.33 per cent) and indoxacarb (26.43 per cent), as well as the regularly used quinolphos (26.35 per cent) and popular pyrethroid, cypermethrin were similarly promising for the control of pink bollworm (27.18 per cent). They also claimed that the widely used chloropyrifos was found to be ineffective with the maximum green boll damage of 92.48 per cent compared to 39.05 per cent in the untreated control.

Kalaiselvi *et al*. (2006) reported that lamda- cyalothrin was effective in lowering bollworm incidence by 61.3-73.6 per cent, respectively when applied at 20, 25 and 30 gm a.i./ha, respectively.

Lakshmi Narayana and Rajasri (2006) reported that flubendiamide @ 50 gm a.i./ha was the most effective against *H. armigera* on cotton when compared to spinosad @ 75 gm a.i./ha and indoxacarb @ 75 gm a.i./ha.

Prasad *et al.* (2007) reported that the synthetic pyrethroids *i.e.* deltamethrin @ 15 gm a.i./ha, lamda cyhalothrin @ 25 gm a.i./ha and thiodicarb @ 750 gm a.i./ha found superior in terms of per cent locule damage in green bolls, larval incidence and seed cotton production. Quinalphos (500 gm a.i/ha) was the next most effective insecticide, whereas chlorpyriphos and profenofos were unsuccessful against pink bollworm.

Wayal *et al.* (2007) stated that lamba-cyhalothrin 5 CS new formulation, at a dose of 50 gm a.i/ha was found to be the most effective in reducing pink bollworm incidence in squares, flowers, green bolls, open bolls and locules and was statistically on par with lamba-cyhalothrin 5 CS new formulation @ 25 gm a.i./ha.

Younis *et al.* (2007) evaluated seven insecticides against the pink bollworm and found that synthetic pyrethroids exhibited greater reduction in bollworm infestation. The per cent reduction in the general average of larvae counted were found to the tune of Gamma-cyhalothrin (93.5%), deltametrin (80.6%), fenvalerate (70.3%), profenophos (61.7%), chlorpyrifos (57.6%) and lambda-cyhalothrin (51.8 %).

Ghure *et al*. (2008) reported that lambda-cyhalothrin 5 EC @ 100 gm a.i./ha was found to be the most effective against cotton bollworms with green boll damage ranging from 10.12 to 12.42 per cent, compared to a maximum of 12.42 per cent in untreated controls (26.80 to 29.23 per cent). In the same treatment, the minimum locule damage was found to be 11.92 per cent. However, indoxacarb 14.5 SC @ 75 gm a.i./ha, spinosad 45 SC @ 75 gm a.i./ha and profenofos 50 EC @1000 gm a.i./ha at par with each other. Seed cotton yields were significantly greater in all insecticides treatments, ranging from 1371 to 1931 kg/ha, compared to 968 kg/ha in the untreated control.

Patil *et al.* (2009) found that at 95 DAS the plots treated with thiodicarb 70 SP (3.29 larvae/20 bolls), followed by profenophos 50 EC (4.76), lambda-cyhalothrin 5 EC (5.23), cyfluthrin 25 EC (6.46), quinalphos 25 EC (6.69) and chlorpyriphos 50 EC (8.15), showed a significant reduction in pink bollworm larvae population. Similar trends were observed for reduction in larval population at 125 and 155 DAS.

Amer *et al*. (2012) reported that, the pupation per cent, adult emergency per cent, oviposition period, egg laying rate, egg hatch ability per cent, fecundity per cent, life cycle and life span of pink bollworm are all reduced by emamectin benzoate. Meanwhile, it raises the mortality rates of pink bollworm larvae, pupae and adults.

Magdy (2012) evaluated various insecticidal sequences against bollworm complex in cotton and found that 93.4 per cent of bolls were protected. It was attained by sequence 7 (Alpha cypermthrin – deltamethrin – lambda cyhalothrin and cypermthrin), while sequence 6 (Acetamiprid – alpha-cypermethrin – chlorfenapyr and profenfos) had the lowest boll protection percentage of 69.9 per cent.

Narkhede and Singh (2012) reported that during 2005-06 and 2006-07, indoxacarb 75 gm a.i./ha and spinosad 48 SC 50 gm a.i./ha were found to be equally effective by registering significantly lower larval populations of 1.42 and 1.45 larvae/ plant, respectively, followed by profenophos 50 EC @ 1000 gm a.i./ ha (1.81 larvae/ plant) and Quinalphos 25 EC @ 400 gm a.i./ha. Significantly lowest per cent fruiting body damage was noticed in the treatment of spinosad 48 SC and indoxacarb 15 SC (19.84 and 20.89 %, respectively) compared to other treatments. However, these treatments were followed by profenophos 50 EC (23.89%) and quinalphos 25 EC (24.95%), but both were on par with each other. These two treatments, indoxacarb 15 SC and spinosad 48 SC, had the highest number of good opened bolls (18.92 and 20.98 bolls/ plant) compared to the untreated control (8.95 bolls/ plant) and were at par with each other followed by profenophos 50 EC. Significantly minimum number of bad opened bolls of 1.88 and 1.98 bolls per plant registered with spinosad 48 SC and indoxacarb 15 SC, respectively as against 10.87 bolls per plant in untreated check. The treatments of spinosad 48 SC and indoxacarb 15 SC proved equally effective by recording higher yield of 19.20 and 19.78 q/ha respectively followed by profenophos 50 EC (12.85 q/ha). The lowest yield was observed in untreated check (7.95 q/ha).

Shivanna *et al*. (2012) observed that three and seven days after treatment, the number of pink bollworm larvae per 20 bolls in novaluron, thiodicarb and spinosad was considerably lower than the number of larvae in control. Whereas thiodicarb, spinosad and lambda cyhalothrin caused the least damage to green bolls. Spinosad, novaluron, indoxacarb, thiodicarb and lambda cyhalothrin all had significantly more Good Opened Bolls (GOBs) than control. Spinosad (1935.20 kg/ha) and indoxacarb (1909.83 kg/ha) had significantly higher seed cotton yields than control (968.60 kg/ha), followed by thiodicarb (1890.10 kg/ha), novaluron (1866.73 kg/ha) and lambda cyhalothrin (1802.17 kg/ha) and NSKE had significantly lower seed cotton yield (1507.27 kg/ha).

Zidan *et al*. (2012) evaluated the efficacy of five insecticides against the pink bollworm, *P. gossypiella*, including two synthetic pyrethroids (cypermethrin, lambda-cyhalothrin), two organophosphorus (profenophos, chlorpyriphos) and one carbamate (methomyl). According to the results, the tested synthetic pyrethroids were the most effective compounds, during the two seasons. The treatments against pink bollworm might be placed descendingly according to the average per cent reduction over control of the two seasons as follows: cypermethrin (81.45 %), lambda-cyhalothrin (71.91 %), methomyl (68.33 %), profenophos (66.75 %) and chlorpyrifos (62.58 %).

Patel (2013) reported that newer insecticide of the avermectine class, emamectin benzoate 5 WSG @ 9.8 gm a.i./ha was found to be the most effective against the pink bollworm, *P. gossypiella,* giving maximum reduction in population and registered maximum increase in yield over control, net profit and being relatively safe against a potent predator of cotton bollworms. However, spinosad 45 SC @ 100 gm a.i./ha and lambda cyhalothrin 5 EC @ 25 gm a.i./ha, found next effective.

Saleh *et al*. (2013) evaluated the efficiency of commercial formulations of four insecticides, *i.e*. pyridalyl, emamectin benzoate, methomyl and methoxyfenozide against pink bollworm, *P. gossypiella*. They found that pyridalyl and emamectin benzoate were the most efficient compounds during the two seasons. The treatments could be arranged in descending order according to the average reduction of two seasons as follows: pyridalyl (52.21 per cent), emamectin benzoate (46.55 per cent), methomyl (38.49 per cent) and methoxyfenozide (34.10 per cent) against pink bollworm.

Salem *et al*. (2013) observed that the profenophos caused high increase in pupal malformation and showed significant reduction in moth emergence percentage of pink bollworm, *P. gossypiella*.

Sabry *et al.* (2014) evaluated the relative toxicity of modern insecticides *viz*., chlorantraniliprole, thimethoxam and spinetoram against pink bollworm, *P. gossypiella*. They found that thiamethoxam was the most effective insecticide followed by chlorantraniliprole and spinetoram. The LC 50 was 8.09, 13.9 and 19 ppm for thiamethoxam, chlorantraniliprole and spinetoram, respectively.

Bajya *et al.* (2015) investigated the bioefficacy of Apligo 150 ZC (chlorantraniliprole 9.3% + lambda-cyhalothrin 4.6 %), chlorantraniliprole, quinalphos, deltamethrin and lambda-cyhalothrin against *P. gossypiella.* Per cent reductions of larval population of *P. gossypiella*, to the tune of 57.36, 63.09, 71.31 and 75.14 per cent were observed for 30, 37.5, 40 and 60 gm a.i./ha doses of Ampligo 150 ZC, respectively. While reduction in *P. gossypiella* larval population reductions were found to the tune of 62.33, 52.19, 36.90 and 27.91 per cent for chlorantraniliprole 18.5 SC 30 gm a.i./ha, lambda-cyhalothrin 4.9 CS 25 gm a.i./ha, quinalphos 25EC 500 gm a.i./ha and deltamethrin 2.8 EC 12.5.

Naik *et al.* (2015) studied the effect of new molecules on bollworm management under high density planting system. They found that among the five selected insecticides, chlorantraniliprole 18.5 SC and flubendiamide 480 SC was recorded the lowest incidence of bollworm at 60 and 80 DAS under high density planting system adopting 45 x 10 cm spacing.

Surpam *et al.* (2015) reported that in case of bollworms, cypermethrin 10 per cent + indoxacarb 10 per cent SC @ 200 + 200 gm a.i./ha (T_6) was the superior treatment in terms of reducing per cent infestation in fruiting bodies (squares, flowers, green bolls) during all observational periods after first, second and third spray and it was however, at par with cypermethrin 10 per cent + indoxacarb 10 per cent SC @ 100 + 100 gm a.i./ha (T_5) and cypermethrin 10 per cent + indoxacarb 10 per cent SC @ 75 + 75 gm a.i./ha (T_4). Among the sole insecticides, indoxacarb 10 per cent SC @ 75 gm a.i./ha (T_{10}) was found to be superior for minimizing per cent infestation in fruiting bodies.

Abbas *et al*. (2017) evaluated the toxicity and latent effects of six insecticides (lambda-cyhalothrin, Mineral oil masrona, indoxacarb, emamectin benzoate, *Bacillus thuringiensis* microbial pesticides and chlorfluazuron) (0.0846, 16548.017, 45.252, 16043.16, 0.154 and 3.0178 ppm concentrations, respectively), to study their effects on the duration of larval, pupal, total immature stages and longevity, fecundity and fertility of adults of pink bollworm, *P. gossypiella*. The obtained results clear that the larval period prolonged to 21.67, 18.27, 20.42, 15.84, 23.50 and 19.65 days compared to 14.63 days in control; while, pupal period estimated by 10.67, 9.97, 9.27, 13.04, 9.1, 11.86 and 8.84 days in treatments and control, respectively. On the other hand, the adult stage resulted from treated larvae was highly affected by all used compounds.

Aziza (2017) evaluated the efficacy of five recommended insecticides, belonging to the organophosphate and synthetic pyrethroid groups against field population of *P. gossypiella* under the laboratory conditions. Results showed that pyrethroid (lambda cyhalothrin) was the most effective insecticide with low to moderate resistance levels, while the organophosphate chlorpyrifos was found to be the least toxic insecticide with high resistance level.

Manikrao (2017) reported that the minimum green boll damage by larvae was recorded in chlorantraniliprole 18.5 SC treated plots.

Bhujade *et al.* (2018) conducted a field trial to assess the performance of newer insecticides combinations against the bollworm complex in cotton The results revealed that application of chlorantraniliprole 8.8 % + thiamethoxam 17.5 % SC proved effective in recording minimum green fruiting bodies damage as well as per cent shed material, which was at par with indoxacarb 14.5 % + acetamiprid 7.7 % SC, chlorantraniliprole 9.3% + lambda cyhalothrin 4.6 % ZC, Thiamethoxam 12.6 % + Lambda cyhalothrin 9.5 % ZC, flubendiamide 19.92 % + thiacloprid 19.92 % SC, spinatorum10 % + sulfoxaflor 30 % WG and thiamethoxam 12.6 % + lambda cyhalothrin 9.5 % ZC.

Borude *et al*. (2018) evaluated the efficacy of ready mix insecticides against cotton bollworm complex. The results revealed that application of indoxacarb 14.5 per cent + acetamiprid 7.7 per cent SC proved effective in recording minimum green fruiting bodies damage as well as least open boll damage due to bollworms, which was closely followed by profenofos 40 per cent + cypermethrin 4 per cent EC, novaluron 5.25 per cent + indoxacarb 4.5 per cent SC and thiamethoxam 12.6 per cent + lambda cyhalothrin 9.5 per cent ZC. Whereas, the treatment of pyriproxifen 5 per cent + fenpropathrin 15 per cent EC proved relatively less effective in this respect.

Divya *et al.* (2020b) evaluated the efficacy of different insecticides against the pink bollworm. The results revealed that, application of chlorantraniliprole 18.5 SC @ 0.21ml/ lit was found superior over the other treatment with minimum larval population (6.67 larvae/ 20 bolls), maximum good open bolls (35.55 GOB/ plant) and highest yield (2002.96 kg/ha).

2.3 Evaluation of Solar Light Trap against Pink Bollworm

Akbulut *et al*. (2003) recorded a total of 109 species from to 17 families of the order Lepidoptera by using light traps at Duzce, Turkey. The Geometridae family was represented by the highest number of species (20) followed by Noctuidae (19), Lycaenidae (12) and Nymphalidae (12).

Keresi and Almasi (2009) studied a total of 179,031 specimens from 177 species and 14 families through light trap catches at northern Serbia. The most abundant species belonged to Noctuidae (54.9%), Pyralidae (27.4%) Geometridae (8.3%) and Arctiidae (6.1%) families.

Nowinszky and Puskas (2009) observed the light-trap catch of all the five species was low during full moon period. Whereas in case of the yellow wooly bear (*Spilosoma virginica*) the forage looper (*Caenurgina erechtea*) and the western bean cutworm (*Striacosta albicosta* Smith) a maximum catch was detectable in the vicinity of a new moon.

Sharma and Vaishampayan (2009) observed 27 species belonging to 8 families of order Lepidoptera in light trap catch at Jabalpur using 125 watt mercury vapour lamp. The largest of these families, Noctuidae had 13 species. The major polyphagous pest species of this family were *Helicoverpa armigera* (120 moths), *Agrotis ipsilon* (84 moths) and *Spodoptera litura* (246 moths). Comparing the relative size of trap catches, the largest catch was observed in case of *Cnaphalocrocis medinalis* (7,988 moths) belonging to family Pyralidae which was a major pest of paddy in this region. Other major

Lepidopteron paddy pest species were *Mythimna separata* (466) and *Melanitis ismene* (122).

Hakyemez and Hzal (2010) using light trap studied during 2006 and 2007 in Kapdag Peninsula. A total of 35 Noctuidae species were collected and identified, representing 12 different subfamilies.

Bernardi *et al.* (2011) reported that a total of 2,020 individuals were caught in a light trap, representing 14 groups, 106 genera and 220 species. Noctuidae (59), Geometridae (30), Arctiidae (28) and Saturniidae (28) were the families with the most species obtained (14).

Shah *et al*. (2011) observed that cotton bollworms, spiny bollworm, *Earias insulana* (Boisduval), spotted bollworm, *Earias vittella (*Fabricius), american bollworm, *Helicoverpa armigera* (Hubner) and pink bollworm, *Pectinophora gossypiella* (Saunders) are major pest of cotton. The light traps and specific sex pheromone traps were used and fixed on one hector area in each locality to monitor the adult population of all species mentioned above. Sex pheromones proved more effective for monitoring the adult moth of all species except *H. armigera*, *i.e*., 48 adults were captured by light traps and only 26 were caught by pheromones, *P. gossypiella* was very attractant to sex pheromones, only 2 % were captured through light trap but response of *Earias* species were positive to both techniques, here also pheromones seemed more successful in capturing the adult moth than light trap with little variation in both years.

Shubhalaxmi *et al.* (2011) studied on light trap collection and observed that a total of 418 species represent 28 families belonging to 15 super families were recorded at eight sites in northern Western Ghats, India and they reported that the main families were Erebidae, Geometridae, Sphingidae and Crambidae.

Sharma and Bisen (2013) reported that, during the *kharif* season of 2006, a total of 56 species were captured in a light trap using a mercury vapour lamp. Of these, 23 species from seven families belonged to the order Lepidoptera in a vegetable cropping area near Jabalpur. They also reported trapping of rice army worm, *Mythimna separata* as a major pest of paddy.

Shimoda and Honda (2013) observed that insects are able to see ultraviolet (UV) radiation. Nocturnal insects are often attracted to light sources that emit large amounts of UV radiation.

Dadmal and Khadakkar (2014) conducted experiments at Panjabrao Deshmukh Krishi Vidyapeeth Akola and examined the species composition of insect fauna attracted towards the light trap. In 2011-12 and 2012-13, observations revealed that the order Coleoptera showed a large population, accounting for 41.81 per cent and 35.10 per cent of the entire collection, respectively, followed by Hemiptera 16.86 per cent and 21.77 per cent and Lepidoptera 12.96 per cent and 12.89 per cent, respectively. In both years, 19 species of scarab beetles from 10 genera were found to be the most common visitors. Subfamily, Melolonthinae had rich species diversity with five species of genus *Holotrichia* and *Schizomycha ruficollis*.

Ullah *et al*. (2015) studied One (T_1) and Two (T_2) light traps/ha were compared with control (traps) with no light-T_3) against gram pod borer, *Helicoverpa armigera* (Hub.). T_1 resulted in 7.57 mean number of *H. armigera* moths out of 49 total moth catch with average population of 0.306 larva per plant with 5.46 % pod damage and average yield of 1980 kg/ha. In T_2, out of 45.26 total moth catch, 5.61 were *H. armigera*, with lowest number of larval population (0.254/ plant), lesser pod damage (4.02 %) and higher yield (2120 kg/ha), while in control plots (T_3), larval population density was maximum with 0.379 larvae/ plant with pod damage of 10.40 % and 1834 kg/ha. yield was recorded. Mean number of 5.82 larval parasitoid were trapped in T_1 while in T_2 there were 5.19 adult parasitoids/ trap.

Adnan *et al.* (2016) studied light trap technique on okra crop at the experimental field of Sind Agriculture University Tando jam. The study was carried out up to thirteen weeks. During the observation period, pest was monitored through light trap and results showed that only *Earias vitella* species were found during observation. The results further revealed that relationship of pest with different phonological stages of the crop, such as vegetative, flowering and fruiting stages. It was recorded that the pest captured in low numbers particularly in vegetative stage of the crop such as, 1st March (0.00), 8th March (0.71), 15th March (1.00), 22nd March (1.00), 29th March (1.00) and flowering stage of the crop the pest captured through light trap were comparatively high such as, 5th April (1.71), 12th April (1.57), 19th April (1.86), 26th April (2.14) and in fruiting stage of okra more number of adult moths were captured through light trap such as, 3rd May (2.29), 10th May (2.29), 17th May (2.57), 24th May (2.43) and 31st May (2.57), respectively. The correlation between temperature and captured moths was positive and significant (r=0.8987**) that indicate the change in temperature affected the prevailing percentage of insects.

Altaf Hussain *et al*. (2016) reported that the terrestrial insects are most diverse groups of animals and contribute to the biodiversity to a large extent. Light trap sampling is commonly used in insect biodiversity studies. A wide variety of light traps with different light designs are being used. Numerous light sources have been used to access the photo response of different insect species since last forty years. However, not all the light sources proved efficient to attract and collect all the nocturnal insect species in a particular habitat. The success of light traps is affected by a wide variety of factors. Environmental conditions, trap design, height of the light source, attraction radius of a light source, surrounding anthopogenic lights, wave length, intensity of light source, timing and duration of light trap, all affect the success of light traps.

Pyae *et al*. (2016) reported the importance of UV light traps which caught 2960 individuals belonging to 481 species from 10 orders and 7080 individuals representing 769 species from 14 orders across 10 sites on six insect orders namely Lepidoptera, Coleoptera, Diptera, Hemiptera, Hymenoptera and Trichoptera were dominant in both areas.

Kalola *et al.* (2017) studied the data pertaining to adult moth catches of pink bollworm *(Pectinophora gossypiella)* and leaf eating caterpillar *(Spodoptera litura)* recorded for nine years (2006- 2014) using the light trap installed at College Agronomy Farm, Anand were analysed in terms of weather parameters obtained from the agrometeorological observatory, Anand. Both the insects were found to be active throughout the year, however their populations were minimum during April to September. The correlation analysis indicated that the most of the weather parameters had negative and significant association except sunshine hours, which has significant positive correlation. The stepwise regression analysis revealed that wind speed and morning vapour pressure could explain 87 per cent variation in pink bollworm, while wind speed and afternoon vapour pressure could explain 65 per cent variation in leaf eating caterpillar.

Abbas *et al*. (2019) reported that the insects attracted towards light trap mainly belong to order Lepidoptera, Hemiptera and Coleoptera.

Gavhande *et al*. (2019) found that the total number of insects caught in blue, yellow and UV-A blue colour light were 6820, 8199 and 19872, respectively during the experimentation. The highest population of Lepidoptera insects was observed in UV-A blue colour light. It could be inferred that the solar insect light trap was technically as well as economically feasible.

3. MATERIALS AND METHODS

The present investigation entitled "Management of Pink Bollworm *Pectinophora gossypiella* (Saunders) in *Bt* Cotton" was carried out during *Kharif* 2020 at All India Coordinated Cotton Improvement Project, MPKV, Rahuri, Dist. Ahmednagar (MH). Investigation on the seasonal incidence of pink bollworm, *P. gossypiella*, on *Bt* cotton, evaluation of different insecticides against *P. gossypiella* and evaluation of solar light trap against *P. gossypiella* were carried out during *Kharif* 2020.

The meteorological data during the experimental period were obtained from the meteorological observatory Mahatma Phule Krishi Vidyapeeth, Rahuri. The different materials used and methods followed during these studies are presented in detailed as under.

3.1 Experimental Site

Field experiment was conducted at All India Coordinated Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, during *kharif* season of the year 2020. The geographical situation of Rahuri is on 19.38°N latitude and 74.65°E longitude, with an elevation of 511 metres above mean sea level.

3.2 Soil Type

The experiment was conducted in black cotton soil.

3.3 Climatic Conditions

Rainfall of Rahuri is uncertain with a mean annual rainfall of 621 mm distributed over a period of five to six month (May- October), with two peaks occurring in July and September. Temperature and relative humidity range from 21 to 92 per cent from 14 to 40 degrees Celsius, respectively.

3.4 Agronomic Practices

The necessary tillage operations were performed as per the requirements, considering the recommendation of Mahatma Phule Krishi Vidyapeeth, Rahuri for growing cotton crop.

3.4.1 Preparatory Tillage

During summer, the soil was thoroughly ploughed by tractor mould board plough followed by two harrowings. Then the field was cleaned by collecting stubbles. The experiment was laid out as given in plan of layout.

3.4.2 Sowing

The sowing was done by hand dibbling by adopting 90 cm x 90 cm spacing by placing 2-3 seeds per hill on 8th July 2020 after receiving optimum rains.

3.4.3 Gap Filling and Thinning

Gap filling was done within 5-7 days after emergence of the crop and thinning was done at 15 days after emergence of crop.

3.4.4 Application of Fertilizers

Application of fertilizers was done @ 120:60:60 kg NPK/ha in the form of urea, single super phosphate, muriate of potash.

3.4.5 Intercultural Operations

Hoeings and weedings were done from time to time to remove weeds and improve soil aeration and also conserve soil moisture.

3.5 To Study Seasonal Incidence of Pink Bollworm on *Bt* Cotton.

3.5.1 Experimental Details

a. Crop	:	*Bt* Cotton
b. Variety	:	Ajeet-199
c. Soil type	:	Black cotton soil
d. Season and year	:	*kharif* 2020-2021
e. Date of sowing	:	8 July 2020
f. Design	:	Half block non replicated
g. Plot size	:	25 m x 20 m (500 m^2)
h. Spacing	:	90 cm x 90 cm
i. Location	:	AICCIP, MPKV, Rahuri

3.5.2 Method of Recording Observation

3.5.2.1 Per cent rosette flowers

The observations on rosette flowers due to pink bollworm infestation were recorded starting from August and continued up to December at weekly interval. In each week after the initiation of flowers, five tagged plants were randomly selected for counting the total number of flowers and number of rosette flowers. Finally, per cent rosette flowers were calculated using the formula below.

$$\text{Per cent rosette flower} = \frac{\text{No. of rosette flower}}{\text{Total no. of flower}} \times 100$$

3.5.2.2 Pink bollworm larval population per 20 green bolls

At 80, 100 and 120 DAS, 20 green bolls from each subplot were taken from 5 randomly selected and tagged plants. Each green boll was carefully cut open along with ridges of the locules with the use of a sharp cutter and the number of live pink bollworm larvae in each boll was estimated by counting the number of live pink bollworm larvae in each boll.

3.5.2.3 Per cent green boll damage

At weekly intervals, the incidence of pink bollworm in green bolls was observed. 20 green bolls were plucked and brought to the laboratory from 5 randomly selected and tagged plants from each subplot. The number of damaged bolls was counted in the laboratory and expressed as a per cent green boll damage.

$$\text{Per cent green boll damage} = \frac{\text{No. of damaged green bolls}}{\text{Total no. of green bolls observed}} \times 100$$

3.5.2.4 Per cent locule damage

At the time of picking total number of locules and damaged locules due to pink bollworm were counted from 5 randomly selected plants and per cent locule damage was calculated.

$$\text{Per cent locule damage} = \frac{\text{No. of damaged locule}}{\text{Total no. of locule}} \times 100$$

3.5.2.5 Per cent opened boll damage

Total number of good opened bolls and bad opened bolls due to pink bollworm were counted at the time of picking from five randomly selected plants, and per cent opened boll damage was calculated.

$$\text{Per cent open boll damage} = \frac{\text{No. of bad open boll}}{\text{Total no. of open boll}} \times 100$$

3.5.2.6 Pheromone trap catch

Three pherosensor sleeve traps were erected at 1-2 m height in plot depending on the crop stage, to monitor the pink bollworm adult emergence from the first week of August till the end of December. Every week adult male moth catches in pheromone traps were recorded.

3.6 Evaluation of Different Insecticides against Pink Bollworm in *Bt* Cotton

3.6.1 Experimental Details

a. Crop	:	*Bt* Cotton
b. Variety	:	Ajeet-199
c. Soil type	:	Black cotton soil
d. Season and year	:	*kharif* 2020-21
e. Date of sowing	:	8 July 2020
f. Design	:	RBD
g. Treatments	:	9
h. Replications	:	3
i. Plot size	:	7.2 m x 5.4 m
j. Spacing	:	90 cm x 90 cm
k. Location	:	AICCIP, MPKV, Rahuri
l. No. of sprays	:	3

Table 3.1. Treatment details

Tr. No.	Treatment	Dose (gm or ml a.i./ha)	Formulation gm/ml/ha.	Dose ml/10 lit.
1.	Profenophos 50 EC	750	1500 ml	30
2.	Indoxacarb 15.8EC	75	500 ml	10
3.	Emamectin benzoate 5 SG	11	220 gm	4
4.	Lambda cyhalothrin 5 EC	20	400 ml	8
5.	Cypermethrin 25 EC	55	220 ml	4
6.	Chlorantraniliprole 18.5 SC	30	150 ml	3
7.	Spinetoram 11.7 SC	50	445 ml	8
8.	Fenpropathrin 30 EC	87.5	295 ml	6
9.	Untreated control	-	--	-

3.6.2 Imposition of Treatments

The list of insecticides used for this study is furnished in Table 3.1. The insecticide sprayings were initiated coinciding with initiation of pink bollworm activity, different sprays were taken as mentioned in above schedule at 60, 75 and 90 DAS. The sprayings were done with knapsack hand compression sprayer discharging 6 lit of spray fluid for each treatment (500 lit spray fluid per hectare).

3.6.3 Method of Recording Observation

The pre-treatment count was taken before spraying for taking decision to initiate imposition of treatments and subsequently post treatment count were recorded after ten days of each spray application. The observations on rosette flowers, per cent green boll damage, larval population per 20 green bolls, per cent open boll damage and per cent locule damage in open boll in each treatment were recorded as explained in previous objective.

3.6.4 Seed Cotton Yield

During the crop season, picking of seed cotton was done manually using human labour at the appropriate time without contamination of plant parts or trash. Individual plot seed cotton yields were recorded in separate pickings and expressed as quintal per ha.

3.6.5 Statistical Analysis

The data on per cent rosette flower, per cent green boll damage, per cent open boll damage and per cent locule damage were subjected to arc sin transformations whereas larval incidence was subjected to square root transformations. The transformed data were analysed using Randomized Block Design.

3.7 Evaluation of Solar Light Trap against Pink Bollworm

3.7.1 Experimental Details

a. Design	:	Not applicable
b. Spacing	:	90 cm x 90 cm
c. Hybrid.	:	Ajeet-155
d. Soil Type	:	Medium black
e. Season & Year	:	*Kharif*, 2020-21
f. Sowing Date	:	8th july 2020
f. Replications	:	Not applicable
g. Treatments	:	Not applicable
h. Location	:	AICCIP, MPKV, Rahuri
i. Trap installation date	:	2020

3.7.2 Trap Installation/ Operation Details

The solar light trap was installed in the centre of cotton field. The trap was automatic on with light detector sensor during night hours and automatic off during day hours. It was provided with high quality solar panel for efficient power harvesting from solar along with high quality UV LED lamp to attract the pests.

3.7.3 Method of Recording Observation

The observations on the number of pink bollworm moths trapped and the beneficial insects trapped in the solar light trap were sorted out, identified and counted. The count of pink bollworm moths and beneficial insects were taken daily from installation of the trap till the harvest of the crop.

4. RESULTS AND DISCUSSION

The results of investigation carried out on the seasonal incidence, evaluation of different insecticides and evaluation of solar light trap against pink bollworm in *Bt* cotton are reported and discussed in this chapter with previous work done by other workers in this regard, under following heads.

4.1 To Study Seasonal Incidence of Pink Bollworm on *Bt* Cotton

The data on moths trapped per trap, per cent rosette flower, per cent green boll damage, pink bollworm larvae per 20 bolls, open boll damage and locule damage in open boll during *Kharif* 2020 in *Bt* cotton presented in Table 4.1 and 4.2.

4.1.1 Pheromone Trap Moth Catch

Three pheromone sleeve trap were placed in a plot to observe the seasonal incidence of pink bollworm starting from first week of August, till the end of December. The moth catches were recorded and presented meteorological week wise in Table 4.1 and Fig. 4.1.

The adult trap catch of pink bollworm started from the month of August and its ranged from 1 to 350 moths/ week. The adult trap catch of pink bollworm increased gradually to its first peak in the last week of October (44^{th} SMW) (117 moths/week), the highest trap catch of adult moth was recorded during 47^{th} SMW (350 moths/week) and thereafter gradually decline till the end of December.

However, the results of present findings are in contrast with Khan *et al*. (2002) who reported that the activity of pink bollworm during October. Sandhya Rani *et al.* (2010) reported the adult trap catches of pink bollworm was started from September and more or less steady till the second week of November.

4.1.2 Rosette Flowers due to Pink Bollworm, *P. gossypiella* (Saunders)

The data on rosette flowers due to pink bollworm in *Bt* cotton (Table 4.1 and Fig. 4.2) ranged from 2.33 to 32.35 per cent occurring from 37^{th} SMW. The highest incidence was recorded in 47^{th} SMW (32.35 per cent).

However, the results of present findings are in contrast with Arshad *et al.* (2015) who reported that the maximum numbers of rosette flowers was observed on 30^{th} July. As per Verma *et al.* (2017) the pink bollworm, *P. gossypiella* infestation on flowers found higher in 2^{nd} week of September with intensity of 7 larvae per 30 flowers. According to Shinde *et al.* (2018) the peak rosette flowers were observed during 47^{th} SMW.

Table 4.1. Seasonal incidence of pink bollworm, *P. gossypiella* on *Bt* cotton

SMW	Duration	Moths /week	Rosette flower (%)	Green boll damage (%)	PBW larval population / 20 green bolls	Temperature (˚C)		Humidity (%)		Rainfall (mm)
						Max.	Min.	Morning	Evening	
31	30-05 Aug	0.00	0.00	0.00	0.00	30.14	20.36	91.43	56.43	107.80
32	06-12 Aug.	0.00	0.00	0.00	0.00	30.43	24.16	83.43	60.71	0.00
33	13-19 Aug.	0.00	0.00	0.00	0.00	27.51	23.20	89.29	74.86	60.20
34	20-26 Aug.	1	0.00	0.00	0.00	27.49	23.26	88.86	71.57	25.80
35	27-02 Sept.	14	0.00	0.00	0.00	29.57	23.33	86.14	60.57	0.80
36	03-09 Sept	4	0.00	0.00	0.00	30.59	23.40	87.00	56.43	4.70
37	10-16 Sept.	7	2.33	0.00	0.00	32.06	23.67	92.43	59.43	82.60
38	17-23 Sept.	5	5.83	1.11	0.26	29.20	23.19	93.00	69.86	209.00
39	24-30 Sept.	8	8.93	3.30	0.87	27.94	23.76	90.29	69.71	68.20
40	01-07 Oct.	13	11.17	5.17	1.60	30.66	22.93	87.71	56.71	1.00
41	08-14 Oct.	26	13.11	8.33	3.43	32.31	23.61	86.00	43.71	8.40
42	15-21 Oct.	67	19.27	14.22	5.37	29.80	23.43	91.71	62.86	49.00
43	22-28 Oct.	47	23.85	24.28	9.45	30.86	22.76	93.14	58.57	0.94
44	29-04 Nov.	117	25.89	33.56	13.58	30.09	19.80	86.86	52.14	0.59
45	05-11 Nov.	54	26.48	34.06	19.33	30.51	16.94	85.86	35.86	0.56
46	12-18 Nov	300	29.73	36.07	21.41	28.41	14.33	83.00	35.57	1.41
47	19-25 Nov.	350	32.35	38.07	23.37	31.29	19.84	85.71	43.29	1.29
48	26-02 Dec.	154	22.43	43.24	38.12	29.00	17.26	84.43	42.00	0.87
49	03-09 Dec.	63	19.83	32.04	22.08	28.77	16.23	86.29	37.71	1.64
50	10-16 Dec.	118	12.50	27.85	20.15	29.54	14.99	78.43	33.29	1.04
51	17-23 Dec.	54	9.60	26.05	18.54	27.43	16.80	90.71	49.43	0.76
52	24-31 Dec.	46	8.33	25.05	16.23	27.34	10.80	86.00	33.00	1.11

4.1.3 Green Boll Damage due to Pink Bollworm, *P. gossypiella* (Saunders)

The data on per cent green boll damage due to *P. gossypiella* in *Bt* cotton (Table 4.1 and Fig. 4.3) ranged between 1.11 to 43.24 per twenty bolls occurring from 38th SMW (1.11 per cent per twenty bolls). The peak incidence was noticed in 48th SMW (43.24 per cent per twenty bolls). Thereafter per cent green boll damage gradually declined.

The findings of earlier workers are more or less in the line of present work. Laxman *et al.* (2014) who reported that infestation of pink bollworm was recorded on *Bt*-cotton in September (12th week of crop). According to Shinde *et al.* (2018) the peak green boll damage was observed in 46th, 47th and 48th SMW.

4.1.4 Pink Bollworm Larvae per Twenty Green Bolls

Table 4.1 and Fig. 4.4 shows that the larval incidence on green bolls in *Bt* cotton varied from 0.26 to 38.12 larvae per twenty green bolls. The incidence started from last week of September (38th SMW) 0.26 larvae per twenty green bolls and later, the larval population increased gradually with first peak of 38.12 larvae per twenty bolls during 48th SMW.

The present findings are in agreement with those of earlier workers like Arshad *et al.* (2015) who reported that the larval number increased in *Bt* cotton in September and October. As per Verma *et al.* (2017) the pink bollworm, *P. gossypiella* peak larval population on bolls was recorded in 3rd week of September. According to Shinde *et al.* (2018) the peak of pink bollworm larval population per 20 green bolls during 46th SMW.

4.1.5 Open Boll Damage due to Pink Bollworm, *P. gossypiella* (Saunders)

The open boll damage recorded due to pink bollworm infestation was ranged from 40.12 to 48.12 per cent from first to third picking. The maximum open boll damage recorded during third picking (48.12 per cent) (Table 4.2 and Fig. 4.5). These results stand in line with Patil (2011), who recorded 22.97 per cent open boll damage during the cropping period.

Similarly, Verma (2017), who reported the open boll damage was 29.99 per cent.

4.1.6 Locule Damage due to Pink Bollworm, *P. gossypiella* (Saunders)

The locule damage due to pink bollworm infestation was varied from 21.48 to 29.12 per cent. The maximum per cent locule damage was recorded during third picking (29.12 per cent) (Table 4.2 and Fig. 4.5).

These result stand in line with Patil (2003), who reported the locule damage of 44.80 per cent to 62.56 per cent during cropping season.

Table 4.2. Open boll damage and locule damage due to pink bollworm, *P. gossypiella* on *Bt* cotton

No. of Picking	Open boll damage (%)	Locule damage (%)
1st	40.12	21.48
2nd	42.35	24.38
3rd	48.12	29.12

4.1.7 Relationship between Weather Parameters and Pink Bollworm in *Bt* Cotton

4.1.7.1 Pheromone trap catch

4.1.7.1.1 Simple correlation studies

The data on correlation between weather parameters and pheromone trap catch presented in Table 4.3.

The pheromone trap catch in relation to morning RH (r = -0.480*) and evening RH (r = -0.521*) were negatively significant. The pheromone trap catch negatively non-significant in relation to minimum temperature (r = -0.446), rainfall (r = -0.308). The pheromone trap catch positively non-significant in relation to maximum temperature (r= 0.035).

The present findings on correlation of pheromone trap catches and weather parameters in line with the findings of Sharma *et al.* (2015), who reported that the pink bollworm pheromone catches showed a significant but negative correlation with minimum temperature (r = -0.79), morning relative humidity (r = -0.59) and evening relative humidity (r = -0.85). Ramesh Babu and Meghwal (2014), reported negative significant correlation with minimum temperature (r = -0.662) and non significant negative with maximum temperature (r = -0.206), rainfall (r = -0.296) and rainy days (r = -0.399).

Table 4.3. Correlation between field incidence of pink bollworm, *P. gossypiella* and weather parameters

Sr. No.	Weather parameters	Moth catch	Rosette flower (%)	Green boll damage (%)	PBW Larvae/20 green bolls
1.	Max. Temp(˚C)	0.035NS	-0.168NS	-0.083NS	-0.215NS
2.	Min. Temp(˚C)	-0.446NS	-0.184NS	-0.663**	-0.696**
3.	Morning RH %	-0.480*	-0.345NS	-0.532*	-0.583*
4.	Evening RH %	-0.521*	-0.370NS	-0.712**	-0.715**
5.	Rainfall (mm)	-0.308NS	-0.495NS	-0.508NS	-0.520*

*= Significant at 5 % **= Significant at 1 % NS= Non significant

4.1.7.2 Rosette flowers due to pink bollworm *P. gossypiella* (Saunders)

4.1.7.2.1 Simple correlation studies

The data on correlation between weather parameters and rosette flower presented in Table 4.3. The rosette flowers negatively non- significant in relationship to maximum temperature (r = -0.168), minimum temperature (r = -0.184), morning RH (r = -0.345), evening RH (r = -0.370) and rainfall (r = -0.495).

Sarode *et al*. (2020) reported that the rosette flowers by *P. gossypiella* showed that negatively non-significant correlation with morning RH and evening RH. Verma *et al*. (2017) who reported that the larval population on flowers shows negative correlation with age of crop, maximum, minimum temperatures and evening relative humidity, on contrary they observed positive correlation with morning relative humidity and rainfall.

4.1.7.3 Green boll damage by pink bollworm *P. gossypiella* (Saunders)

4.1.7.3.1 Simple correlation studies

The data on correlation between weather parameters and green boll damage presented in Table 4.3.

The green boll damage in relation to minimum temperature (r = -0.663**), morning RH (r = -0.532*) and evening RH (r = -0.712**) were negatively significant. The green boll damage negatively non- significant in relationship to maximum temperature (r = -0.083) and rainfall (r = -0.508).

4.1.7.4 Larval population of pink bollworm *P. gossypiella* (Saunders) in green bolls

4.1.7.4.1 Simple correlation studies

The data on correlation between weather parameters and larval population presented in Table 4.3. The larval population of pink bollworm in relation to minimum temperature (r = -0.696**), morning RH (r = -0.583*), evening RH (r = -0.715**) and rainfall (r= -0.520*) were negatively significant. The population of pink bollworm larvae negatively non- significant in relationship to maximum temperature (r = -0.215).

4.2 Evaluation of Different Insecticides against Pink Bollworm in *Bt* Cotton

4.2.1 Rosette Flowers

It is clear from the Table 4.4 and Fig. 4.6 that all tested insecticides found significantly superior over control (31.48 per cent mean rosette flower) in reduction of the rosette flowers due to pink bollworm larvae *P. gossypiella* during the 1st, 2nd, and 3rd spray. Mean per cent rosette flower ranged between 7.44 to 13.54 per cent in different treatments.

Amongst the tested insecticides, chlorantraniliprole 18.5 SC was found to be most effective treatment which induce highest effect, representing 76.37 % reduction in rosette flower over control. However, it was followed by the treatments spinetoram 11.7 SC and lambda cyhalothrin 5 EC which were at par with chlorantraniliprole 18.5 SC and recorded

73.32 % and 69.50 % reduction over control respectively. Next best treatment was indoxacarb 15.8 EC with 64.45 % reduction in rosette flower over control. Profenophos 30 EC, emamectin benzoate 5 SG, fenpropathrin 30 EC and cypermethrin 25 EC were at par with indoxacarb 15.8 EC and recorded 61.34 %, 60.48 %, 58.35 % and 56.99 % reduction in rosette flower over control, respectively.

The present findings on rosette flowers due to *P. gossypiella* corroborate with the results of Naik *et al*. (2015) who reported that chlorantraniliprole 18.5 SC recorded the lowest incidence of bollworm at 60 and 80 DAS. Wayal *et al.* (2007) reported that the lambda- cyhalothrin 5 EC formulation, a dose of 50 g a.i./ha proved to be most effective in reducing pink bollworm incidence in flower.

Table 4.4. Efficacy of different insecticides on rosette flower due to pink bollworm, *P. gossypiella* (Saunders) under field conditions

Tr. No.	Treatments	Dose gm or ml a.i./ha	Rosette flower (%)					ROC (%)
			Precount	1st Spray	2nd Spray	3rd Spray	Mean	
1.	Profenophos 50 EC	750	14.00 (21.96)	14.11 (22.05)	12.07 (20.32)	10.33 (18.74)	12.17 (20.41)	61.34
2.	Indoxacarb 15.8 EC	75	14.11 (22.05)	13.67 (21.69)	11.35 (19.68)	8.55 (17.00)	11.19 (19.54)	64.45
3.	Emamectin benzoate 5 SG	11	13.67 (21.69)	14.33 (22.23)	12.33 (20.55)	10.67 (19.06)	12.44 (20.65)	60.48
4.	Lambda cyhalothrin 5 EC	20	13.00 (21.13)	12.44 (20.64)	9.33 (17.78)	7.03 (15.37)	9.60 (18.04)	69.50
5.	Cypermethrin 25 EC	55	14.67 (22.51)	15.33 (23.04)	14.00 (21.96)	11.28 (19.62)	13.54 (21.58)	56.99
6.	Chlorantraniliprole 18.5 SC	30	14.67 (22.51)	10.67 (19.06)	7.33 (15.70)	4.33 (12.01)	7.44 (15.83)	76.37
7.	Spinetoram 11.7 SC	50	13.67 (21.69)	11.15 (19.50)	8.67 (17.12)	5.38 (13.41)	8.40 (16.84)	73.32
8.	Fenpropathrin 30 EC	87.5	14.33 (22.23)	15.01 (22.79)	13.33 (21.41)	11.00 (19.36)	13.11 (21.22)	58.35
9.	Untreated (control)	-	14.33 (22.23)	22.11 (28.04)	32.67 (34.85)	39.67 (39.02)	31.48 (34.12)	
		SE(m)	0.73	0.80	0.90	1.13	0.78	
		CD at 5%	NS	2.38	2.69	3.38	2.33	
		CV%	9.00	9.62	11.57	5.44	8.94	

(Figures in parenthesis are arcsine transformed values). (ROC- Reduction Over Control) (NS- Non significant)

4.2.2 Green Boll Damage

It is evident from Table 4.5 and Fig. 4.7 that the mean per cent green boll damage due to pink bollworm ranged between 8.78 to 13.41 per cent in different treatments which were significantly superior over control (32.68 per cent) in reduction of the green boll damage during 1st, 2nd and 3rd sprays. Data showed that amongst tested insecticides, chlorantraniliprole 18.5 SC induce highest effect, representing 73.13 % reduction in green boll damage over control.

However, it was followed by the treatments spinetoram 11.7 SC and lambda cyhalothrin 5 EC which were at par with chlorantraniliprole 18.5 SC and recorded 70.20 % and 67.01 % reduction over control, respectively. Next best treatment was indoxacarb 15.8 EC with 63.31 % reduction in green boll damage over control. Profenophos 30 EC, emamectin benzoate 5 SG, fenpropathrin 30 EC and cypermethrin 25 EC were at par with indoxacarb 15.8 EC and recorded 61.78 %, 61.05 %, 60.25 % and 58.97 % reduction in green boll damage over control, respectively.

The present findings on green boll damage due to *P. gossypiella* are in line with the results of Naik *et al*. (2015), who found that the chlorantraniliprole 18.5 SC recorded the lowest incidence of bollworm at 60 and 80 DAS. Similarly, the present findings are in confirmed with Manikrao (2017) who reported that minimum green boll damage by larvae was recorded in chlorantraniliprole 18.5 SC treated plots.

Table 4.5. Efficacy of different insecticides on green boll damage due to pink bollworm, *P. gossypiella* under field conditions

Tr. No.	Treatments	Dose gm or ml a.i./ha	Green boll damage (%)					ROC (%)
			Precount	1st Spray	2nd Spray	3rd Spray	Mean	
1.	Profenophos 50 EC	750	12.67 (20.84)	16.01 (23.58)	13.27 (21.35)	8.18 (16.61)	12.49 (20.68)	61.78
2.	Indoxacarb 15.8 EC	75	13.03 (21.15)	15.42 (23.11)	12.67 (20.84)	7.88 (16.30)	11.99 (20.25)	63.31
3.	Emamectin benzoate 5 SG	11	13.33 (21.41)	16.33 (23.83)	13.49 (21.54)	8.38 (16.82)	12.73 (20.90)	61.05
4.	Lambda cyhalothrin 5 EC	20	12.67 (20.84)	15.19 (22.93)	11.07 (19.43)	6.07 (14.26)	10.78 (19.16)	67.01
5.	Cypermethrin 25 EC	55	13.48 (21.53)	17.01 (24.35)	14.13 (22.07)	9.10 (17.55)	13.41 (21.48)	58.97
6.	Chlorantraniliprole 18.5 SC	30	12.33 (20.55)	13.55 (21.59)	9.33 (17.78)	3.45 (10.70)	8.78 (17.23)	73.13
7.	Spinetoram 11.7 SC	50	12.67 (20.84)	14.08 (22.03)	10.12 (18.54)	5.03 (12.96)	9.74 (18.18)	70.20
8.	Fenpropathrin 30 EC	87.5	12.67 (20.84)	16.65 (24.07)	13.65 (21.67)	8.67 (17.12)	12.99 (21.12)	60.25
9.	Untreated (control)	-	12.45 (20.65)	24.52 (29.67)	33.25 (35.26)	40.00 (39.22)	32.68 (34.82)	-
		SE(m)	0.57	0.45	0.93	1.19	1.00	
		CD at 5%	NS	1.35	2.77	3.58	2.99	
		CV%	7.68	9.54	11.00	6.50	12.37	

Figures in parenthesis are arcsine transformed value) (ROC- Reduction Over Control)
(NS- Non significant)

4.2.3 Pink Bollworm Larvae/ 20 Bolls

Table 4.6. Efficacy of different insecticides on larval population of pink bollworm, *P. gossypiella* under field conditions

Tr. No.	Treatments	Dose gm or ml a.i./ha	Pink Bollworm Larvae/ 20 Bolls					ROC (%)
			Precount	1st Spray	2nd Spray	3rd Spray	Mean	
1.	Profenophos 50 EC	750	6.36 (2.62)	9.33 (3.14)	6.82 (2.70)	4.59 (2.26)	6.91 (2.72)	57.61
2.	Indoxacarb 15.8 EC	75	7.40 (2.81)	8.18 (2.95)	6.26 (2.60)	4.33 (2.20)	6.26 (2.60)	61.60
3.	Emamectin benzoate 5 SG	11	6.15 (2.58)	9.13 (3.10)	7.49 (2.83)	5.45 (2.44)	7.35 (2.80)	54.91
4.	Lambda cyhalothrin 5 EC	20	7.67 (2.86)	7.92 (2.90)	5.33 (2.42)	3.47 (1.99)	5.57 (2.46)	65.83
5.	Cypermethrin 25 EC	55	7.11 (2.76)	9.44 (3.15)	7.67 (2.86)	5.60 (2.47)	7.57 (2.84)	53.56
6.	Chlorantraniliprole 18.5 SC	30	6.45 (2.64)	3.98 (2.12)	3.02 (1.88)	2.26 (1.66)	3.09 (1.89)	81.04
7.	Spinetoram 11.7 SC	50	7.33 (2.80)	5.04 (2.35)	4.17 (2.16)	3.03 (1.88)	4.08 (2.14)	74.97
8.	Fenpropathrin 30 EC	87.5	6.52 (2.65)	9.00 (3.08)	7.78 (2.88)	5.90 (2.53)	7.56 (2.84)	53.62
9.	Untreated (control)	-	6.93 (2.73)	14.04 (3.81)	16.33 (4.10)	18.52 (4.36)	16.30 (4.10)	-
		SE(m)	0.54	0.27	0.19	0.12	0.21	
		CD at 5%	NS	0.80	0.56	0.35	0.61	
		CV%	13.70	11.07	10.79	11.96	6.43	

(Figures in parenthesis are square root transformed value) (ROC- Reduction Over Control) (NS- Non significant)

The results of the present study indicated that, all treatments proved superior over the control (Table 4.6 and Fig. 4.8). Mean larval population per twenty bolls ranged between 3.09 to 7.57 in different treatments. Obtained results showed that amongst tested insecticides, chlorantraniliprole 18.5 SC induce highest effect, representing 81.04 % reduction in larval population over control. However, it was followed by the treatments spinetoram 11.7 SC and lambda cyhalothrin 5 EC which were at par with chlorantraniliprole 18.5 SC and recorded 74.97 % and 65.83 % reduction over control respectively. Next best treatment was indoxacarb 15.8 EC with 61.60 % reduction in larval population over control. Profenophos 30 EC, emamectin benzoate 5 SG, fenpropathrin 30 EC and cypermethrin 25 EC were at par with indoxacarb 15.8 EC and recorded 57.61 %, 54.91 %, 53.62 % and 53.56 % reduction in larval population over control, respectively.

The present findings on larval population of *P. gossypiella* per twenty bolls are in line with the results of Divya *et al*. (2020b), who found that the chlorantraniliprole 18.5 SC recorded the lowest larval population. The present findings regarding pink bollworm larval population per twenty green bolls corroborate with the results of Naik *et al.* (2015) and Bajya *et al.* (2015), who reported that the chlorantraniliprole 18.5 SC was found effective with 62.33 % reduction in *P. gossypiella* larval population.

4.2.4 Open Boll Damage

Based on number of bad opened bolls and good opened bolls at each picking, the per cent open boll damage was calculated and presented in Table 4.7.

Table 4.7. Efficacy of different insecticides on open boll damage and locule damage due to pink bollworm, *P. gossypiella* and yield under field conditions (mean of three picking)

Sr. No.	Treatments	Dose gm or ml a.i./ha	Open boll damage (%)	ROC (%)	Locule damage (%)	ROC (%)	Yield (q/ha)
1.	Profenophos 50 EC	750	9.76 (18.20)	69.76	5.65 (13.75)	81.25	15.25
2.	Indoxacarb 15.8 EC	75	9.17 (17.62)	71.58	5.45 (13.49)	81.91	15.78
3.	Emamectin benzoate 5 SG	11	10.16 (18.58)	68.52	5.89 (14.04)	80.45	13.25
4.	Lambda cyhalothrin 5 EC	20	8.74 (17.19)	72.92	5.19 (13.16)	82.77	17.85
5.	Cypermethrin 25 EC	55	10.46 (18.86)	67.59	6.64 (14.93)	77.96	11.73
6.	Chlorantraniliprole 18.5 SC	30	7.26 (15.62)	77.50	4.09 (11.66)	86.43	20.45
7.	Spinetoram 11.7 SC	50	7.96 (16.38)	75.33	4.64 (12.43)	84.60	19.11
8.	Fenpropathrin 30 EC	87.5	10.24 (18.66)	68.27	6.23 (14.45)	79.32	13.09
9.	Untreated (control)	-	32.27 (34.60)	-	30.13 (33.28)	-	9.85
		SE(m)	0.66		0.52		0.92
		CD at 5%	1.98		1.56		2.75
		CV%	9.96		7.82		10.46

(Figures in parenthesis are arcsine transformed value) (ROC- Reduction Over Control)
(NS- Non significant)

It is evident from Table 4.7 and Fig. 4.9 that the mean per cent open boll damage was significantly less in all treatments (7.26 to 10.46 per cent) which were superior over control (32.27 per cent). Obtained results showed that amongst tested insecticides, chlorantraniliprole 18.5 SC induce highest effect, representing 77.50 % reduction in open boll damage over control. However, it was followed by the treatments spinetoram 11.7 SC and lambda cyhalothrin 5 EC which were at par with chlorantraniliprole 18.5 SC and recorded 75.33 % and 72.92 % reduction over control respectively. Next best treatment was indoxacarb 15.8 EC with 71.58 % reduction in open boll damage over control. Profenophos 30 EC, emamectin benzoate 5 SG, fenpropathrin 30 EC and cypermethrin 25 EC were at par with indoxacarb 15.8 EC and recorded 69.76 %, 68.52 %, 68.27 % and 67.59 % reduction in open boll damage over control, respectively.

The present findings on open boll damage due to *P. gossypiella* are in line with the results of Divya *et al*. (2020b), who found that the chlorantraniliprole 18.5 SC recorded the maximum good open boll and minimum bad open boll with higher cotton yield.

4.2.5 Locule Damage

It is evident from Table 4.7 and Fig. 4.9 that the mean per cent locule damage was significantly less in all treatments (4.09 to 6.64 per cent) which were superior over control (30.13 per cent). Obtained results showed that amongst tested insecticides, chlorantraniliprole 18.5 SC induce highest effect, representing 86.43 % reduction in locule damage over control. However, it was followed by the treatments spinetoram 11.7 SC and lambda cyhalothrin 5 EC which were at par with chlorantraniliprole 18.5 SC and recorded 84.60 % and 82.77 % reduction over control respectively. Next best treatment was indoxacarb 15.8 EC with 81.91 % reduction in locule damage over control.Profenophos 30 EC, emamectin benzoate 5 SG, fenpropathrin 30 EC and cypermethrin 25 EC were at par with indoxacarb 15.8 EC and recorded 81.25 %, 80.45 %, 79.32 % and 77.96 % reduction in locule damage over control, respectively.

The present findings on locule damage due to *P. gossypiella* are in line with the results of Divya *et al*. (2020b), who found that the chlorantraniliprole 18.5 SC recorded the minimum locule damage. Similarly, the present findings are in confirmed with Manikrao (2017), who reported that minimum open locule damage by larvae was recorded in chlorantraniliprole 18.5 SC treated plots.

4.2.6 Yield

The results showed significant difference in yield over control in different treatment as indicated in Table 4.7.

Among the tested insecticide highest seed cotton yield was obtained in chlorantraniliprole 18.5 SC (20.45 q/ha) which was found at par with spinetoram 11.7 SC (19.11 q/ha) and lambda cyhalothrin 5 EC (17.85 q/ha). Next best treatment was indoxacarb 15.8 EC (15.78 q/ha) which was at par with Profenophos 30 EC (15.25 q/ha), emamectin benzoate 5 SG (13.25 q/ha) and fenpropathrin 30 EC(13.09 q/ha). However, lowest yield was recorded in the cypermethrin 25 EC (11.73 q/ha).

The present findings on seed cotton yield collaborate with the results of Divya *et al*. (2020b) who reported highest seed cotton yield in chlorantraniliprole 18.5 SC. The results on the yield in different plots of insecticidal treatments are in accordance with Manikrao (2017) who recorded highest seed cotton yield in chlorantraniliprole 18.5 SC.

4.2.7 Economics of the Different Insecticides

The ICBRs of different treatments was worked out (Table 4.8. and Fig. 4.11.). Among different tested insecticides the highest ICBR *i.e.* 1:19.25 was observed in spinetoram 11.7 SC followed by lambda cyhalothrin 5 EC (1:17.98), chlorantraniliprole 18.5 SC (1:12.28) and indoxacarb 15.8 EC (1:11.63). Lowest ICBR was observed in cypermethrin 25 EC (1:3.75).

4.3 Evaluation of Solar Light Trap against Pink Bollworm

Light traps are the important component of Integrated Pest Management against various crop pest. These traps only attract the adult stage of different insects. So these traps are indirectly important to reduce adult population in the field thus suppresses the larval population of various pests. During current studies main focus was to attract pink bollworm and evaluate the solar light trap against pink bollworm. Three species of beneficial insects were attracted through light trap. The species of beneficial insects were attracted towards light trap were lady bird beetle, spider and chrysopa. The other non-target species/insects attracted were American bollworm, aryworm, cutworm, whitefly, green stink bug, stink bug, grey weevil and earwig.

4.3.1 Pink Bollworm Moths Trapped per Night

The solar light trap was installed in the centre of cotton field. The observation on moth catches start from the date of installation of trap till the last week of December. The moth catches were recorded and presented meteorological week wise in Table 4.9 and Fig. 4.12.

The adult trap catches of pink bollworm started from 38th meteorological week and its ranged from 4.85 to 140.57 moths per night. The adult trap catch of pink bollworm increased gradually to its first peak with highest trap catch in the last week of November

Table 4.8. Economics of different insecticides for control of pink bollworm in *Bt* cotton

Sr. No.	Treatments	Formal gm or ml/ ha	Cost of insecticide (Rs/ ha)	Cost of labour (Rs/ha)	Treatments cost (Rs/ha)	Cost of cultivation (Rs/ha)	Total cost (Rs/ha)	Yield (q/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	Income difference (Rs/ha)	BCR	ICBR
1.	Profenophos 50 EC	1500	1410	2175	3585	42000	45585	15.25	88831.25	43246.25	27870	1.95	7.77
2.	Indoxacarb 15.8 Ec	500	560	2175	2735	42000	44735	15.78	91918.5	47183.5	31807.25	2.05	11.63
3.	Emamectin benzoate5SG	220	440	2175	2615	42000	44615	13.25	77181.25	32566.25	17190	1.73	6.57
4.	Lambda cyhalothrin 5EC	400	280	2175	2455	42000	44455	17.85	103976.25	59521.25	44145	2.34	17.98
5.	Cypermethrin 25 EC	220	132	2175	2307	42000	44307	11.73	68327.25	24020.25	8644	1.54	3.75
6.	Chlorantraniliprol e 18.5 SC	150	2475	2175	4650	42000	46650	20.45	119121.25	72471.25	57095	2.55	12.28
7.	Spinetoram 11.7 SC	445	489	2175	2664	42000	44664	19.11	111315.75	66651.75	51275.5	2.49	19.25
8.	Fenpropathrin 30 EC	295	460	2175	2635	42000	44635	13.09	76249.25	31614.25	16238	1.71	6.16
9.	Untreated (control)	-	-	-	-	42000	42000	9.85	57376.25	15376.25	-	1.37	

Selling price of seed cotton: Rs. 5825/q., Labour charges: Rs. 290/day, MRP: Profenophos 50 EC: Rs.940/lit, Indoxacarb 15.8 EC: Rs. 1120/lit, Emamectin benzoate 5 SG: Rs. 2000/Kg, Lambda cyhalothrin 5 EC: Rs. 700/lit, Cypermethrin 25 EC: Rs. 600/lit, Chlorantraniliprole 18.5 SC: Rs. 2475/150ml, Spinetoram 11.7 SC: Rs. 1100/lit, Fenpropathrin 30 EC: Rs. 1560/lit.

(47th SMW) (140.57 moths per night) and thereafter gradually decreases till the last week of December.

Abbas *et al.* (2019) reported that insects attracted towards light trap mainly belong to order Lepidoptera, Hemiptera and Coleoptera. Kalola *et al.* (2017) reported that the incidence of *P. gossypiella* started from 37th SMW, gradually increased and reached at peak during 5th SMW.

4.3.2 Beneficial Insects

4.3.2.1 Lady bird beetle

Table 4.9 and Fig. 4.13, show that the adult trap catch of lady bird beetle started from 38th SMW and its ranged from 0.57 to 3.71 lady bird beetle per night. The highest trap catch of lady bird beetle in the 39th SMW (3.71 lady bird beetle per night). The second highest catch of lady bird beetle was in the 45th SMW (3.28 lady bird beetle per night).

Abbas *et al.* (2019) reported that four natural enemies of different pest were attracted towards light trap of which Lady bird beetle had 174 captures during study year.

Table 4.9. Evaluation of solar light trap against pink bollworm

SMW	Duration	PBW moth/ Night	PBW moth/ Week	Laddy bird beetle/ Night	Spider/ Night	Chrysopa/ Night
31	30-05 Aug	0.00	0.00	0.00	0.00	0.00
32	06-12 Aug.	0.00	0.00	0.00	0.00	0.00
33	13-19 Aug.	0.00	0.00	0.00	0.00	0.00
34	20-26 Aug.	0.00	0.00	0.00	0.00	0.00
35	27-02 Sept.	0.00	0.00	0.00	0.00	0.00
36	03-09 Sept	0.00	0.00	0.00	0.00	0.00
37	10-16 Sept.	0.00	0.00	0.00	0.00	0.00
38	17-23 Sept.	4.85	34	2.14	3.14	1.42
39	24-30 Sept.	5.71	40	3.71	2.28	1.14
40	01-07 Oct.	12.42	87	2.85	1.85	0.85
41	08-14 Oct.	21.14	148	2.71	1.71	0.85
42	15-21 Oct.	96.57	676	2.42	1.57	0.71
43	22-28 Oct.	100.71	705	2.28	1.42	0.57
44	29-04 Nov.	72.28	506	2.14	2.28	0.42
45	05-11 Nov.	100.14	701	3.28	2.14	0.57
46	12-18 Nov	120.85	846	2.71	1.28	0.71
47	19-25 Nov.	140.57	984	2.57	0.85	0.57
48	26-02 Dec.	54.14	379	1.57	0.71	0.42
49	03-09 Dec.	40.00	280	1.14	0.57	0.28
50	10-16 Dec.	51.85	363	0.85	0.42	0.00
51	17-23 Dec.	16.14	113	0.71	0.42	0.28
52	24-31 Dec.	9.00	63	0.57	0.28	0.00

4.3.2.2 Spider

Table 4.9 Fig. 4.13 show that the adult trap catch of spider started from 38th SMW and its ranged from 0.28 to 3.14 spider per night. The highest trap catch of spider in the 38th SMW (3.14 spider per night). The second highest catch of spider was in the 44th SMW (2.28 spider per night).

4.3.2.3 Chrysopa

Table 4.9 Fig. 4.13 show that the adult trap catch of chrysopa started from 38th meteorological week and its ranged from 0.28 to 1.42 chrysopa per night. The highest trap catch of chrysopa in the 38th SMW (1.42 chrysopa per night).

Abbas *et al.* (2019) reported that four natural enemies of different pest were attracted towards light trap of which *Chrysoperla carnea* had maximum 529 captures during study year.

5. SUMMARY AND CONCLUSIONS

Results of investigation on seasonal incidence of pink bollworm on *Bt* cotton, evaluation of different insecticides against pink bollworm in *Bt* cotton and evaluation of solar light trap against pink bollworm are summarized below.

5.1 Summary

5.1.1 Seasonal Incidence of Pink Bollworm on *Bt* Cotton

The adult trap catches by pheromone ranged from 1 to 350 male moths per week with highest during 47th SMW. Rosette flower ranged between 2.33 to 32.35 per cent. The maximum rosette flowers were observed during 47th SMW. The per cent green boll damage in *Bt* cotton ranged from 1.11 to 43.24 per twenty bolls. The highest green boll damage was observed during 48th SMW. The number of pink bollworm larvae per twenty bolls ranged from 0.26 to 38.12. The maximum pink bollworm larvae per twenty green bolls was during 48th SMW.

Moreover, open boll damage and locule damage ranged from 40.12 to 48.12 per cent and 21.28 to 29.12 per cent, respectively.

5.1.2 Correlation between Weather Parameters and Pink Bollworm in *Bt* Cotton

The pheromone trap catch in relation to, morning and evening RH were negatively significant and negatively non- significant in relation to minimum temperature and rainfall. The pheromone trap catch was positively non-significant in relation to maximum temperature.

The rosette flowers negatively non-significant in relation to maximum temperature, minimum temperature, morning RH, evening RH and rainfall. Green boll damage in relation to minimum temperature, morning and evening RH were negatively significant and negatively non- significant in relation to maximum temperature and rainfall. Larval population in relation to minimum temperature, morning RH evening RH and rainfall were negatively significant and negatively non- significant in relation to maximum temperature.

5.1.3 Evaluation of Different Insecticides against Pink Bollworm in *Bt* Cotton

Among the tested insecticides chlorantraniliprole 18.5 SC was found effective against pink bollworm, recording lowest rosette flower (7.44 %), green boll damage (8.78 %) and pink bollworm larvae (3.09/ 20 bolls). At harvest, chlorantraniliprole 18.5 SC recorded less open boll damage (7.26 %) and locule damage (4.09 %). For all the recorded observations spinetoram 11.7 SC and lambda cyhalothrin 5 EC were found at par with chlorantraniliprole 18.5 SC. Whereas cypermethrin 25 EC was found least effective in management of pink bollworm.

Among tested insecticides chlorantraniliprole 18.5 SC produced highest yield of seed cotton (20.45 q/ha) which was found at par with spinetoram 11.7 SC (19.11 q/ha) and lambda cyhalothrin 5 EC (17.73 q/ha). Among different tested insecticides the highest ICBR *i.e*. 1:19.25 was registered in spinetoram 11.7 SC followed by lambda cyhalothrin 5 EC (1:17.98), chlorantraniliprole 18.5 SC (1:12.28) and indoxacarb 15.8 EC (1:11.63). Lowest ICBR was observed in cypermethrin 25 EC (1:3.75).

5.1.4 Evaluation of Solar Light Trap against Pink Bollworm

The adult trap catches of pink bollworm ranged from 4.85 to 140.57 moths per night with its peak in the 47^{th} SMW. The adult trap catches of lady bird beetle ranged from 0.57 to 3.71 lady bird beetle per night with its peak in the 39^{th} SMW. The adult trap catches of spiders ranged from 0.28 to 3.14 spider per night. The peak spider catch in the 38^{th} SMW. The adult trap catches of chrysopa ranged from 0.28 to 1.42 chrysopa per night. The peak chrysopa catch was in the 38^{th} SMW.

5.2 Conclusions

Seasonal incidence of pink bollworm on *Bt* cotton and their correlation with weather parameters may assist to develop the suitable forecasting model in initiation of insecticide application.

Evaluation of different insecticides against pink bollworm in *Bt* cotton indicated that all the insecticides tested were found significantly superior over untreated control. Chlorantraniliprole 18.5 SC was found most effective for the control of rosette flower, green boll damage, larval population, open boll damage and locule damage. It was at par with the insecticides spinetoram 11.7 SC and lambda cyhalothrin 5 EC.

However the seasonal activity of pink bollworm and beneficial insects on *Bt* cotton were observed in solar light trap catches operated in field regularly in considerable numbers from date of trap installation to the last week of December. Two to three peaks were observed in general, showing period of highest and lowest activity both.

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7. APPENDIX

Details of meteorological data during meteorological period

Month	Week No.	Temperature		Humidity %		Rainfall (mm)	Rainy Days	Evaporation (mm)
		Max.	Min.	Morn.	Even.			
June	23	31.11	23.41	87.14	57.00	93.20	5.00	7.91
	24	33.40	24.96	82.86	45.29	18.40	4.00	5.50
	25	32.43	24.07	86.71	51.57	75.40	3.00	5.06
	26	32.97	24.86	86.14	47.86	78.20	3.00	4.97
July	27	31.94	24.36	89.00	57.00	67.60	4.00	4.19
	28	31.69	24.87	81.43	54.43	2.00	1.00	5.54
	29	31.09	24.03	85.57	60.57	81.00	3.00	4.37
	30	30.23	23.51	90.86	65.86	109.30	4.00	3.71
August	31	30.14	20.36	91.43	56.43	107.80	6.00	4.63
	32	30.43	24.16	83.43	60.71	0.00	0.00	4.74
	33	27.51	23.20	89.29	74.86	60.20	5.00	4.17
	34	27.49	23.26	88.86	71.57	25.80	4.00	3.11
	35	29.57	23.33	86.14	60.57	0.80	0.00	5.51
September	36	30.59	23.40	87.00	56.43	4.70	1.00	4.99
	37	32.06	23.67	92.43	59.43	82.60	4.00	4.49
	38	29.20	23.19	93.00	69.86	209.00	4.00	3.11
	39	27.94	23.76	90.29	69.71	68.20	5.00	3.37
Oct-20	40	30.66	22.93	87.71	56.71	1.00	0.00	4.64
	41	32.31	23.61	86.00	43.71	8.40	1.00	5.01
	42	29.80	23.43	91.71	62.86	49.00	3.00	4.03
	43	30.86	22.76	93.14	58.57	0.94	7.09	97.60
	44	30.09	19.80	86.86	52.14	0.59	7.66	0.00
Nov-20	45	30.51	16.94	85.86	35.86	0.56	8.70	0.00
	46	28.41	14.33	83.00	35.57	1.41	9.30	0.00
	47	31.29	19.84	85.71	43.29	1.29	8.79	0.00
	48	29.00	17.26	84.43	42.00	0.87	8.11	0.00
Dec-20	49	28.77	16.23	86.29	37.71	1.64	8.40	0.00
	50	29.54	14.99	78.43	33.29	1.04	7.83	0.00
	51	27.43	16.80	90.71	49.43	0.76	4.77	0.00
	52	27.34	10.80	86.00	33.00	1.11	8.94	0.00
Total rainfall (mm)						**1153.67**		
Av. Rainfall (mm) of the year						**535.00**		

8. VITAE

Mr. PATHAN YASINKHA KAUSARKHA

MASTER OF SCIENCE (AGRICULTURE)

In

AGRICULTURAL ENTOMOLOGY

2021

Title of thesis		:	**"Management of Pink Bollworm *Pectinophora gossypiella* (Saunders) in *Bt* Cotton"**
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