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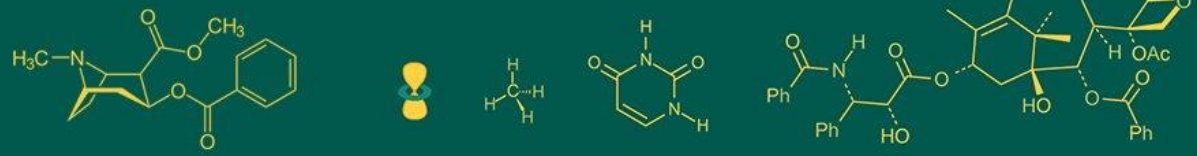

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KM Vora
M.Sc. Scholars,
Department of Agricultural Entomology. COA, JAU, Junagadh, Gujarat, India

Dr. YH Ghelani
Associate Professor and Assistant Registrar, Office of the Registrar, JAU, Junagadh, Gujarat, India

NM Kachhadiya
Subject Matter Specialist, Department of Plant Protection, Krishi Vigyan Kendra, JAU, Amreli, Gujarat, India

BV Patoliya
Assistant Professor and Assistant Registrar Department of Academic, Office of the Registrar, JAU, Junagadh, Gujarat, India

Dr. MK Ghelani
Assistant Professor, Department of Agricultural Entomology, COA, JAU, Junagadh, Gujarat, India

Corresponding Author:
NM Kachhadiya
Subject Matter Specialist, Department of Plant Protection, Krishi Vigyan Kendra, JAU, Amreli, Gujarat, India

Influence of abiotic factor on incidence of Pink bollworm, *Pectinophora gossypiella* (SAUNDERS) on *Bt* cotton

KM Vora, Dr. YH Ghelani, NM Kachhadiya, BV Patoliya and Dr. MK Ghelani

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Abstract
The present research on "Influence of abiotic factor on incidence of pink bollworm, *Pectinophora gossypiella* (Saunders) infesting *Bt* cotton" was carried out at Village: Daliya, Ta. Gondal, Dist. Rajkot during *Kharif*, 2020-21. The results of experiment were revealed that percent rosette flower were continuously increased and get its first peak (12.80 percent/plant) during 40th SMW and second peak (11.20 percent/plant) was observed on 45th SMW, then declined up to the harvest of the crop. The maximum temperature and bright sunshine hours were significantly positively correlated with rosette flower. Larval population was increased and get its first peak (7.00 larvae/20 bolls) during 43rd SMW. The second peak (7.00 larvae/20 bolls) was observed on 46th SMW (23rd WAS) and then declined up to the harvest of the crop. The bright sunshine hours was found highly significant and correlated positively with larval population. The morning and evening relative humidity were found highly significant with negative correlation, while the minimum temperature and wind velocity were found significant with negative correlation with larval population. Percent green boll damage were continuously increased and get its first peak (24.80 percent/plant) during 44th SMW. The second peak (16.80 percent/plant) was observed on 48th SMW and then declined continuously up to the harvest of the crop. The male moth caught from 26th SMW (1.50 moths/trap/week) to 2nd SMW (1.00 moths/trap/week) and ranged from 1.50 to 13.50 per trap/week during the entire crop period.

Keywords: *Bt* cotton, insecticides, pink bollworm, abiotic factor

Introduction
Cotton (*Gossypium sp.*) is one of the principal commercial fiber crop grown under diverse agro-climatic conditions around the world which belongs to the family Malvaceae. The word "Cotton" derived from the Arabic word "alqatan". Cotton is one of the oldest fiber known to mankind. The plant is a shrub native to tropical and subtropical regions around the world, including the America, Africa, Egypt and India. *Gossypium sp.* Comprising about 40 species of which four are commercially cultivated for cotton lint and seed. Cotton crop cultivated in more than seventy countries in the world. Cotton crop is playing an important role in economic, political and social affairs of the world. Cotton crop as commercial commodity plays an important role in industrial activity of nation, in terms of both employment generation and foreign exchange. India is an important cotton grower on a global scale. It is also known as white gold and king of appraisal fiber which is important raw material for textile industry.

India, United States, China, Brazil, Pakistan are the leading cotton producing countries in the world (Anon., 2019) [2]. India commands highest share (36%) in terms of area under cotton cultivation in the world. India is the largest producer of cotton in the world accounting for about 25 percent of the world cotton production. In India, cotton was cultivated under 133.73 lakh hectare area with production of 365 lakh bales (1 bale=170 kg) and productivity of 464 kg per hectare during 2019-20 (Anon., 2018) [3].

The cotton crop is attacked by 1326 species of insect pests throughout the world, of which about 130 different species of insects and mites found to devour cotton at different stages of crop growth in India. Spotted bollworm (*Earias vitella* Fabricius), American bollworm (*Helicoverpa armigera* Hubner), pink bollworm (*Pectinophora gossypiella* Saunders), leaf

eating caterpillar (*Spodoptera litura* Fabricius), aphid (*Aphis gossypii* Glover), jassid (*Amrasca biguttula biguttula* Ishida), thrips (*Thrips tabaci* Lindeman), whitefly (*Bemisia tabaci* Gennadius), mite (*Tetranychus telarious* Linnaeus), mealy bug (*Phenacoccus solenopsis* Tinsley) and dusky cotton bug (*Oxycarenus laetus* Kirby) are the major insect pests attacking the cotton crop (Davidson and Lyon 1978) [4].

Among major insect pests attacking the cotton, pink bollworm, *P. gossypiella* [Lepidoptera: Gelechiidae] is the one of the most destructive and serious pest of cotton cultivation and has known to cause losses in seed cotton yield, oil content, loss in normal opening of bolls, damage of locules, and reduction in seed cotton yield.

The management of pink bollworm on cotton has become a tough task because the larval stages of this pest were spent in the cotton bolls. Therefore, conventional control methods including insecticidal application are difficult to control this pest.

Hence, fluctuation in relation to biotic and abiotic factors there is a need to study the seasonal incidence for better understanding of the pest to formulate control strategies for effective management of pink bollworm.

Materials and Methods

In order to study the seasonal incidence of pink bollworm in *Bt* cotton field experiment was carried out during *Kharif* 2020-21. Cotton crop variety Nawab (PCH-4599) was sown at Village: Daliya, Ta. Gondal, Dist. Rajkot. The crop was grown in plot size of 10.8 x 9.6 m area at a distance of 90 x 60 cm spacing between row to row and plant to plant. All the recommended agronomical practices were followed to raise the cotton crop. The plot was kept free from insecticidal spray throughout the season.

Method of recording observations

The cotton plot was divided in ten quadrate of sized 3.6 m x 2.4 m. Five plant were selected randomly and tagged from each quadrate, thus total 50 plant were observed at weekly interval. Pest population was recorded at weekly interval starting from 15 days after sowing to harvest of crop. Observation on number of healthy and damaged (rosette) flower/square, green bolls and number of larvae were recorded per plant. At harvesting time, healthy and damaged open bolls and locules per plant were recorded. With a view to study the impact of different abiotic on pest abundance, a simple correlation between pest population and weather parameters [maximum (MaxT) &minimum temperature (MinT), morning (RH_1) & evening relative humidity (RH_2), bright sunshine hrs (BSS), wind velocity and rainfall]was worked out as per the method given by Steel and Torrie (1960) [12]. The weekly meteorological data were obtained from the meteorological observatory of Main Dry Farming Research Station, JAU, Targhadia (Rajkot).

Rosette flower/ bud damage

At the time of flowering, number of healthy and rosette flowers were counted from five randomly selected plants from each quadrate. Based on this, percent rosette flowers per plant were worked out by using following formula.

$$\text{Rosette flower (\%)} = \frac{\text{Number of rosette flowers}}{\text{Total healthy flowers}} \text{ X } 100$$

Green boll damage

Five plants were randomly selected from each quadrate, the number of healthy and damaged bolls by pink bollworm were counted and expressed in terms of percent green boll damage asit was worked out by using following formula.

$$\text{Green boll damage (\%)} = \frac{\text{Number of damaged green bolls}}{\text{Total number of green bolls observed}} \text{ X } 100$$

Open boll damage

At the time of each picking, number of healthy and damaged bolls were recorded from five randomly selected plants from each quadrate. Based on this, percent open boll damage was worked out by using following formula.

$$\text{Open boll damage (\%)} = \frac{\text{Damaged open bolls}}{\text{Total open bolls}} \text{ X } 100$$

Locule damage

At the time of each picking, number of healthy and damaged locule were counted from five randomly selected plants from each quadrate. Based on this, percent locules damage was worked out by using this formula.

$$\text{Locule damage (\%)} = \frac{\text{Damaged locules}}{\text{Total numbers of locules}} \text{ X } 100$$

Pheromone catch/trap/week

Two pheromone traps were set up in experimental unit to know about seasonal fluctuation of moth of pink bollworm, *P. gossypiella*. The data on moth catches were recorded at weekly interval from traps and lures were changed at fifteen days interval up to the harvest of the crop.

Results and Discussion

To know the effect of weather parameters on the occurrence and abundance of *P. gossypiella* in *Bt* cotton, a study was carried out during *Kharif*2020-21 at Village: Daliya, Ta. Gondal, Dist. Rajkot. The data on larval population, rosette flower and green boll damage were recorded from the cotton plants and also correlated with the various abiotic factors to determine the relationship with the pest.

The data on percent rosette flower per plant caused by *P. gossypiella* during *Kharif* 2020-21 on *Bt* cotton (Table 1) revealed that the flower damage was noticed from 33rd Standard Meteorological Week (SMW) and tenth week after sowing (WAS) (0.80% rosette flower/plant) to 52ndSMW and 29th WAS (0.40% rosette flower/plant). The percent rosette flower damage was observed in range of 0.40 to 12.80/plant during the entire crop period. Initially very low percent rosette flower was observed from 33rdto 36th SMW which were ranged from 0.80 to 3.60 percent rosette flower/plant. Thereafter, percent rosette flower were continuously increased and get its first peak (12.80 percent/plant) during 40th SMW (17th WAS). The increasing rate of rosette flower were declined in subsequent four week but after that again the trend was increasing. The second peak (11.20 percent/plant) was observed on 45th SMW (22nd WAS) and then declined up to the harvest of the crop.

Table 1: Seasonal incidence of pink bollworm, *P. gossypiella* infesting *Bt* cotton during *Kharif*, 2020-21

Sr. No	WAS	SMW	Rosette flower per plant (%)	No. of pink bollworm larvae/20 bolls	Green boll damage per plant (%)
1	10	33	0.80	0.00	0.00
2	11	34	1.20	0.00	0.00
3	12	35	1.60	0.00	0.00
4	13	36	3.60	1.00	1.60
5	14	37	4.80	1.00	2.80
6	15	38	6.40	2.00	6.40
7	16	39	9.60	3.00	8.40
8	17	40	12.80	2.00	11.20
9	18	41	11.20	4.00	13.60
10	19	42	10.40	6.00	18.00
11	20	43	9.20	7.00	18.80
12	21	44	7.20	5.00	24.80
13	22	45	11.20	4.00	20.40
14	23	46	10.80	7.00	17.60
15	24	47	10.00	5.00	14.40
16	25	48	9.20	6.00	16.80
17	26	49	6.80	5.00	14.80
18	27	50	3.60	3.00	11.60
19	28	51	1.60	4.00	8.40
20	29	52	0.40	2.00	5.20
21	30	1	0.00	2.00	3.60
22	31	2	0.00	1.00	1.60

SMW: Standard Meteorological Week, **WAS:** Week after sowing

The flower damage was not found the onward 1st& 2nd SMW (30th& 31stWAS) due to lack of flower.

The data on larval population of pink bollworm, *P. gossypiella* during *Kharif* 2020-21 on *Bt* cotton (Table 1) revealed that the larvae in bolls were noticed from 36th Standard Meteorological Week (SMW) and 13th week after sowing (WAS) (1.00 larvae/20 bolls) to 2nd SMW and 31st WAS (1.00 larvae/20 bolls). The larval population was observed in range of 1.00 to 7.00 larvae/20 bolls during the entire crop period. Initially very low population of larva was observed from 36th to 38th SMW which were ranged from 1.00to 2.00larvae/20 bolls Thereafter, larval population were increased and get its first peak (7.00 larvae/20 bolls) during 43rdSMW (20th WAS). The increasing rate of larval population was declined in subsequent two week but after that again the trend was increasing. The second peak (7.00larvae/20 bolls) was observed on 46th SMW (23th WAS) and then declined up to the harvest of the crop.

The data on percent green boll damage per plant caused by *P. gossypiella* during *Kharif* 2020-21 on *Bt* cotton (Table 1) revealed that the green boll damage was noticed from 36th Standard Meteorological Week (SMW) and 13th week after sowing (WAS) (1.60% green boll damage/plant) to 2nd SMW and 31st WAS (1.60% green boll damage /plant). The percent green boll damage were observed in range of 1.60 to 24.80/plant during the entire crop period. Initially very low percent green boll damage were observed from 36th to 37th SMW which were ranged from 1.60 to 2.80 percent green boll damage /plant. Thereafter, percent green boll damage were continuously increased and get its first peak (24.80 percent green boll damage/plant) during 44th SMW (21th WAS). The increasing rate of green boll damage was declined in subsequent three week but after that again the trend was increasing. The second peak (16.80 percent/plant) was observed on 48th SMW (25th WAS) and then declined continuously up to the harvest of the crop.

The data on percent open boll and locule damage per plant caused by *P. gossypiella* during *Kharif* 2020-21 were counted during 1st, 2nd, 3rd and 4th picking and **(**Table 2) the data showed that open boll damage was 19.60, 26.40, 22.80 and 17.20 percent during 1st, 2nd, 3rd and 4th picking, respectively. Whereas, locule damage was 14.75, 20.50, 16.25 and 16.06 percent during 1st, 2nd, 3rd and 4th picking, respectively. At the time of harvesting the open boll and locule damage was

Table 2: Seasonal incidence of pink bollworm, *P. gossypiella* infesting *Bt* cotton during *Kharif*, 2020-21 (At harvesting time)

Sr. No.	No. of pickings	Open boll damage (%)	Locule damage (%)
1	1st picking	19.60	14.75
2	2nd picking	26.40	20.50
3	3rd picking	22.80	16.25
4	4th picking	17.20	12.75
	Mean	21.50	16.06
	SD ±	3.99	3.29

recorded the highest during the 2nd picking with 26.40 and 20.50 percent, respectively.

The data on number of caught moths per trap per week of *P. gossypiella* during *Kharif* 2020-21 (Table 3) revealed that the moth catching was noticed from 26th SMW and 3rd WAS (1.50 moths/trap/week) to 2nd SMW and 31st WAS (1.00 moths/ trap/week). The caught moths were observed in range of 1.50 to 13.50 moths/trap/week during the entire crop period. Initially very less no. of moths/trap/week were observed from 26thto 28thSMW which were ranged from 1.50 to 4.50 moths/trap/week. Thereafter, increase in moth population was observed from 33rd SMW (10 WAS) to 42nd SMW (19 WAS) and get its first peak (13.50 moths/trap/week) during 42ndSMW (19th WAS). The increasing rate of caught moths were declined in subsequent three week but after that again the trend was increasing. The second peak (11.00 moths/trap/week) was observed on 47th SMW (24th WAS) and then declined continuously up to the harvest of the crop.

Khuhro *et al.* (2015) [6] observed the male moth catches of *P. gossypiella*in trap occurred during 31st to 52nd SMW

which was fluctuated every year with maximum moth catched during 40th to 43rd SMW. The peak pink bollworm pheromone catches were recorded during 42nd SMW (Sharma *et al.*, 2015) [9].

The available literature revealed that the peak level of pink bollworm in *Bt* cotton was observed during 44th SMW (21 WAS) to 52nd SMW (29 WAS) (Ajmad *et al.*, 2016) [1]. Rawal *et al.* (2017) [8] reported that incidence of bollworms on squares started from 32nd SMW (9 WAS) and continue till harvesting of crop.

Table 3: Average moth catch/trap/week and effect of abiotic factors on moth population of pink bollworm infesting *Bt* cotton during *Kharif*, 2020-21

WAS	SMW	No. of moths/trap/week	Temperature (°C)		Relative humidity (%)		BSS (hrs./day)	WV (km/hr.)	Rainfall (mm)
			Max.	Min.	Morning	Evening			
2	25	0.00*	37.1	26.0	83	57	6.8	7.2	7.2
3	26	1.50	37.2	26.2	80	47	7.0	6.4	6.4
4	27	3.50	33.8	25.4	89	69	4.5	5.5	5.5
5	28	4.50	32.2	24.9	90	75	4.5	6.6	6.6
6	29	5.00	33.8	25.1	84	65	5.0	5.3	5.3
7	30	6.50	34.2	24.9	82	62	7.4	4.8	4.8
8	31	5.00	34.3	24.4	91	70	4.6	3.5	3.5
9	32	5.50	30.4	23.6	92	84	1.5	6.3	6.3
10	33	3.50	29.9	24.0	94	86	0.4	5.0	5.0
11	34	5.50	29.6	23.6	92	84	2.6	7.2	7.2
12	35	6.00	32.9	24.0	89	65	7.6	3.1	3.1
13	36	7.50	33.8	24.3	89	64	6.4	3.5	3.5
14	37	7.00	33.4	23.9	88	74	5.3	3.5	3.5
15	38	8.50	33.3	24.0	86	68	6.7	4.5	4.5
16	39	9.00	34.6	22.7	84	61	8.6	4.1	4.1
17	40	10.00	36.0	22.4	82	56	9.0	4.0	4.0
18	41	12.00	35.7	23.7	84	59	7.2	4.3	4.3
19	42	13.50	34.5	19.7	70	39	9.8	3.3	3.3
20	43	12.50	34.2	17.4	55	30	9.4	2.6	2.6
21	44	10.50	33.3	15.6	54	34	8.5	3.1	3.1
22	45	9.00	31.7	13.5	61	34	8.2	3.7	3.7
23	46	10.50	30.0	12.6	69	36	8.8	4.3	4.3
24	47	11.00	33.5	15.5	60	38	8.9	2.6	2.6
25	48	10.00	32.0	13.9	69	51	7.0	3.3	3.3
26	49	8.50	27.3	11.1	53	45	8.0	4.3	4.3
27	50	9.50	29.1	11.2	64	35	8.7	2.7	2.7
28	51	8.50	28.5	10.8	67	38	8.4	2.9	2.2
29	52	6.00	27.8	11.4	63	36	8.6	3.7	1.9
30	1	3.50	24.4	8.4	69	40	7.4	4.6	0.00
31	2	1.00	26.4	10.9	65	46	7.6	5.0	0.00

SMW: Standard Meteorological Week; **WAS:** Week after sowing *: mean of two traps; **BSS**: Bright Sunshine Hour; **WV**: Wind Velocity; **Max.:** Maximum Temperature; **Min.:** Minimum Temperature

Verma *et al.* (2017) [13] recorded 28.88 and 17.22 percent open boll damage and open locule damage, respectively in *Kharif* 2012, while it was recorded 29.99 and 18.05 percent, respectively in *Kharif* 2013. Shinde *et. al.* (2018) [10] revealed that the peak of flower resetting, green boll damage, pink bollworm larval population per 20 green bolls and locule damage in green bolls was observed during 45th, 46th and 47th MW, respectively in *Bt* cotton. However, the peak green boll damage was observed in 46th, 47th and 48th MW. Divya *et al.* (2020) [5] reported that the pink bollworm incidence was started during 32nd SMW and attended its severity at 46th (15 larvae/20 bolls).

In the present study, the pink bollworm population was at the highest level during 46th SMW (23th WAS), while damage on flower and bolls was during 40th SMW (17th WAS) and 44th SMW (21st WAS), respectively. The Moth population of pink bollworm was observed from 33th SMW to 42nd SMW and its first peak was recorded during 42th SMW (19th WAS). Hence, the above reports are more or less accordance with the present finding.

Effect of weather parameters on *P. gossypiella* population: The correlation data (Table 4) showed the maximum temperature (r = 0.690*) and bright sunshine hours (r = 0.432*) were significantly positively correlated with rosette flower. The minimum temperature (r = 0.227) and rainfall (r = 0.371) were positively correlated with rosette flower which was also found non-significant. The morning relative humidity (r = -0.129), evening relative humidity (r = -0.188) and wind velocity (r = -0.264) were negatively correlated with percent rosette flower but was found non-significant.

The correlation data indicated that the bright sunshine hours (r = 0.608**) was found highly significant and correlated positively with larval population. The morning relative humidity (r = -0.659**) and evening relative humidity (r = -0.677**) were found highly significant negative correlation with larval population. The minimum temperature (r = -0.376*) and wind velocity (r = -0.442*) were found significant negative correlation with larval population. The maximum temperature (r = 0.164) and the rainfall (r = -0.006) were found non-significant with positive and negative correlation with larval population of pink bollworm, respectively.

Table 4: Correlation between weather parameters and *P. gossypiella* incidence on *Bt* cotton

Pink bollworm Abiotic factors	Correlation co-efficient ('r')			
	No. of moths/trap/week	Rosette flower (%)	No. of pink bollworm larvae/20 bolls	Green boll damage (%)
Maximum Temperature (°C)	0.292	0.690*	0.164	0.299
Minimum Temperature (°C)	-0.221	0.227	-0.376*	-0.283
Morning Relative Humidity (%)	-0.439*	-0.129	-0.659**	-0.660**
Evening Relative Humidity (%)	-0.459*	-0.188	-0.677**	-0.653**
Bright Sunshine Hours (hrs./day)	0.585**	0.432*	0.608**	0.589**
Wind Velocity (km/hr.)	-0.645**	-0.264	-0.442*	-0.434*
Rainfall	-0.140	0.371	-0.006	0.087

n=30 *Significant at 5% level (r = ± 0.361); **Significant at 1% level (r = ± 0.462)
n=21 *Significant at 5% level (r = ± 0.433); **Significant at 1% level (r = ± 0.549)

Correlation between green boll damage and weather parameter showed the bright sunshine hours (r = 0.589**) was observed highly significant with positive correlation. The morning relative humidity (r = -0.660**) and evening relative humidity (r = -0.653**) were negatively correlated which were found highly significant. The wind velocity (r = -0.434*) was found significant with negative correlation. The maximum temperature (r = 0.299) and rainfall (r = 0.087) were positively correlated but non-significant. The minimum temperature (r = -0.283) was negatively correlated but was found non-significant with green boll damage.

The correlation data indicated that the bright sunshine hours (r = 0.585**) and the wind velocity (r = -0.645**) were found highly significant with positive and negative correlation with moth catches/trap/week, respectively. The morning relative humidity (r = -0.439*) and evening relative humidity (r = -0.459*) were found significant with negative correlation with moth catch/trap/week. The maximum temperature (r = 0.292) was positively correlated with moth catch/trap/week but was found non-significant. The minimum temperature (r = -0.221) and rainfall (r = -0.140) were found negatively correlated with moth catch/trap/week but non-significant. Ramesh Babu and Meghwal (2014) [7] found that pheromone trap catches of pink bollworm showed negative significant correlation with minimum temperature (r = -0.662). However it showed negative non-significant correlation with morning relative humidity (r = -0.499), evening relative humidity (r =-0.496), rainfall (r = -0.296). Rosette flower and larvae per bolls showed positive significant correlation with maximum temperature whereas green boll damage showed positive correlation but non-significant. Rosette flower had positive correlation with rainfall but non-significant. Whereas green boll damage had positive correlation with minimum temperature but non-significant (Shravan *et al.*, 2017) [11]. Divya *et al.* (2020) [5] reported that the correlation results of the meteorological variables with insect population revealed that pink bollworm showed significant positive correlation with maximum temperature and non-significant negative correlation with minimum temperature, evening relative humidity and rainfall.

In present findings more or less similar trend is observed, hence our findings are accordance with the findings of earlier researches.

Conclusion

From the overall results of the present investigation, it can be concluded that the pink bollworm larval population was initiated during the 36th Standard Meteorological Week (SMW) to 2nd Standard Meteorological Week (SMW). Whereas pink bollworm moth population was initiated during 26th Standard Meteorological Week (SMW) to 2nd Standard Meteorological Week (SMW).

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