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Research Paper

Influence of meteorological factors on trap catches and incidence of pink bollworm, *Pectinophora gossypiella* (Saunders) on *Bt* cotton

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ABSTRACT

The pink bollworm incidence and adult male moth trap catches were monitored throughout the cropping period for four years from 2017-2021 on *Bt* cotton (KCH-14K59) at the University of Agricultural Sciences, Raichur. The pink bollworm male moth activity (95 moths/trap) was higher during the month of December month (49th SMW) with the highest larval incidence (25.67 larvae / 20 bolls) on green bolls during the month of February (6th - 9th SMW). The correlation matrix indicating the relationship between the weekly mean moth catches, larval incidence and meteorological variables from 2017 to 2021 exerted negative association with the mean of maximum and minimum temperature, rainfall, morning and afternoon relative humidity. However, the influence of all these whether parameters was found to be highly significant. When the data was subjected to Multi Linear Regression analysis, the results revealed that 78.70 per cent of mean pheromone trap catches ($R^2 = 0.787$) and 92 per cent of mean larval incidence ($R^2 = 0.92$) were negatively influenced by minimum temperature.

***keywords**:* Pink bollworm, Trap catches, Larval incidence, Correlation, Multiple regression

Cotton (Gossypium spp.), the king of natural fibers referred to as white gold is grown in more than 111 countries of tropical and sub-tropical regions as a commercial crop. Cotton is known for its seed fiber and oil from seed, which plays a prominent role in the national and international economy. India is an important cotton grower among all the cotton producing countries in the world and ranks first in area (119.10 lakh ha) with production of 312.03 lakh bales of 170 kg each with productivity of 445 kg lint ha^{-1} (Anonymous, 2022). About 130 different species of insects and mites are reported to cause damage to cotton crop of which pink bollworm, *Pectinophora gossypiella* (Saunders) is the major damaging insect pest across India leading to severe loss to cotton production (Dhurua and Gujar, 2011). Pink bollworm neonates within a few hours after hatching enter into the young bolls or flowers and feed on cotton seeds or flowers causing rosette flower, partial or premature boll opening, locule damage, double seed formation and reduction in staple length of fibre.

After the introduction of *Bt* cotton in the year 2002 the cotton area gradually increased from 0.29 lakh ha in 2002-03 to 33.53 lakh ha in 2006-07 (PIB, 2020), due to absolute bollworm check and a 40-60 % reduction in pesticide usage (Khadi, 2007), and enhanced net profit up to 78 per cent (Rao and Dev, 2009). However, field resistance developed against the *Bt* cotton by pink bollworm (PBW) in India (Dhurua and Gujar, 2011) resulted in more damage (40-95 %) with 20-30 per cent yield loss, despite the use of novel chemical insecticides (Fand *et al*., 2019). To adopt integrated pest control measures, it is still essential to comprehend how meteorological variables affect trap captures and the prevalence of PBW.

Weather factors *viz*., temperature, humidity and rainfall play a vital role in shaping insect pest populations, and which significantly influence on pest life cycle, distribution and behaviour (Kalola *et al.,* 2017; Pooja *et al.,* 2022). These parameters directly affect the insect development, survival and reproduction potential of pink bollworm. Understanding this circuitous interconnection between weather variables and pink bollworm dynamics is essential

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for predicting outbreaks, designing effective control measures and optimizing the use of *Bt* cotton. The present study mainly aims to investigate the relationship between weather factors, trap catches of pink bollworms, and their subsequent incidence on *Bt* cotton. By examining these interactions, we can gain valuable insights into the dynamics of pink bollworm populations and enhance our understanding of the efficacy of *Bt* cotton in different climatic conditions.

MATERIALS AND METHODS

Trap catches serve as an important tool for monitoring and estimating pest populations. The use of pheromone traps to capture male moths and the incidence of PBW provide a means to assess the population dynamics. A field experiment was conducted at the Main Agricultural Research Station (MARS), Raichur. The *Bt* cotton hybrid (KCH-14K59) was sown in an area of two hectare and the crop was raised as per recommended agronomical practices (POP, 2021). The pheromone sleeve traps were installed at two pheromone traps per acre and trap catches were monitored throughout the cropping season for four years *viz*., 2017-18, 2018-19, 2019-20 and 2020-21. The septum with Pectino-lure (Manufactured by Pheromone Chemicals, Nacharam, Hyderabad) was changed 15 days interval during the observation period. A collection of moths from each trap was made once in two days and a total number of pink bollworm moths was pooled separately for every standard week and the mean number of catches of pink bollworm per trap per standard week was calculated. Observations on seasonal larval incidence of pink bollworm were recorded by destructive sampling of 20 bolls per acre and the destructive sampling was done at weekly interval from 60 days after sowing till the harvest of the crop.

In order to find out the impact of environmental factors on trap catches and the incidence of pink bollworm on *Bt* cotton, weather parameters such as rainfall, maximum temperature, minimum temperature, morning and afternoon relative humidity were collected from the meteorology department of MARS, Raichur. Along with the average weekly weather parameters, four years of data on larval incidence and trap catches were subjected to correlation analysis and multiple linear regression analysis technique by fitting different functions by using R software.

RESULTS AND DISCUSSION

Pheromone trap catches of pink bollworm

The weather data of four years (2017-18, 2018-19, 2019-20 and 2020-21) from the 35th SMW to 3rd SMW was utilised to study the correlation of trap catches with weather parameters and the average trap catches and weather parameters of four years represented was in Table 1. However, during the year 2020-21 trap catches were recorded from 30th SMW to 9th SMW. The PBW moth catches in pheromone traps were noticed throughout the cropping period of all the four years. In the year 2017-18, from 35th to 3rd SMW three peaks were noticed *viz.*, the first week of January (1st SMW) with 170.76 moths per trap per week, which was followed by the third week of January (3rd SMW) with 158.70 and second week of October (41st SMW) with 48.48 moths per trap per week, respectively. Similarly, during 2018-19, three peak moth catches were noticed *viz.*, third week of November (47th SMW) 95.20 moths per trap per week which was followed by the second week of January (2nd SMW) with 22.14 and the third week of August (34th SMW) with 4.08 moths per trap per week, respectively. While, during 2019-20, five peaks moth catches were noticed at the first week of December (49th SMW) with 131.90 moths per trap per week which was followed by the third week of December (51st SMW) with 121.20, third week of November (47th SMW) with 97.10, third week of January (3rd SMW) with 74.56 and first week of September (36th SMW) with 9.64 moths per trap per week, respectively.

In the year 2020-21, from 30th to 9th SMW seven peak moth catches were noticed *viz.*, the second week of November (46th SMW) with 108.39 male moths per trap per week which was followed by the fourth week of November (48th SMW) with 72.07, the third week of December (51st SMW) with 54.88, the first week of January (1st SMW) with 21.26, the first week of September (36th SMW) with 9.64, the first week of February (6th SMW) with 3.31 and fourth week of September (39th SMW) with 2.21 pink bollworm male moths per trap per week, respectively. The varied peak activity might be due to the weather factors and availability of the preferred crop stage of the host plants.

The first peak of pink bollworm trap catches appeared during the month of August/ September, due to congenial environment parameters. The emerged moths lay eggs, but neonates die due to lack of flowers or bolls which serves as a source of food or the cotton plants with vegetative growth. However, from the second fortnight of September the trap catches increased steadily and peaked during the month of December due to synchronicity of flower/ bolls stage of cotton and convivial weather factors mainly minimum temperature. The trap catches were started decreasing from January onwards, due to increased maximum temperature and occurrence of rainfall in the study area. The pink bollworm trap catches results are in agreement with Muttappa and Patil (2019) who recorded six peaks of pink bollworm trap catches *viz*., October second week, November first week and November third week, December second week, January second and fourth week. Correspondingly, Prasad *et al.,* (2009) observed the peak activity of pink bollworm from November to January but also varied activity over the years. These results are similar to the end results of the current investigation. The variation in trap catches of PBW moths might be due to changes in sowing time, availability of host plants and weather factors.

Larval incidence of pink bollworm in green bolls

The seasonal incidence of pink bollworm larvae was recorded from unprotected bolls by destructive sampling method which was done at weekly intervals from 60 days after sowing till the harvest of the crop from 2017 to 2021. Weekly data were pooled and mentioned as month wise and represented in Table 2. However, weekly data on average PBW larval incidence and weather parameters of the four years (33rd - 52nd SMW) was represented in Table 1. The results showed that the pink bollworm incidence started from August (5.30 larvae / 20 bolls) in 2017-18, from October month in both 2018-19 (3.00 larvae / 20 bolls) and 2020-21 (0.80 larvae / 20 bolls), but in the year 2019-20 incidence was noticed from the November month (6.20 larvae / 20 bolls). Pink bollworm incidence

Table 1: Mean pheromone trap catches and larval incidence of pink bollworm moths during cotton growing seasons from 2017 to 2021 at MARS, Raichur

SMW	Trap Catches*	No. of larvae per 20 bolls*	Temperature (°C)		Rainfall (mm)	Relative humidity (%)	
			Maximum	Minimum		Morning	Afternoon
33	-	1.1	30.9	23.5	26.2	88	64
34	4.3	1.5	32.2	23.1	23.1	87	56
35	5.6	1.5	32.2	23.1	33.8	88	58
36	8.1	1.6	32.1	23.5	20.9	85	57
37	6.6	1.6	32.9	23.7	32.7	85	56
38	6.0	1.8	30.6	22.8	82.3	90	68
39	14.0	1.8	31.1	22.8	95.3	93	69
40	18.6	2.1	31.6	23.4	34.2	89	63
41	21.2	1.9	31.8	22.3	59.8	89	60
42	18.1	3.1	31.1	22.6	20.7	89	64
43	20.5	3.4	31.5	21.7	18.1	85	55
44	35.3	4.8	31.2	20.5	0.0	80	51
45	63.0	7.0	31.7	19.8	0.0	81	47
46	91.3	9.2	31.4	20.0	0.0	79	46
47	92.4	10.3	31.7	20.4	0.0	81	44
48	86.8	10.8	29.3	18.8	3.2	79	49
49	95.0	11.1	29.9	19.0	0.0	82	48
50	81.2	12.0	31.0	17.3	0.0	83	39
51	92.4	14.1	29.3	16.2	0.0	83	45
52	82.9	15.2	29.8	17.2	0.0	81	44
1	66.9	-	30.2	18.7	0.5	81	46
2	64.2	-	30.7	18.6	0.2	81	42
3	63.5	-	31.2	18.1	0.3	79	40

SMW = Standard Meteorological week; * = Mean of four-year data from 2017-2021

gradually increased and reached its peak in the February month (22.30, 26.20 and 28.50 larvae / 20 bolls during 2018-19, 2019-20 and 2020-21, respectively) again incidence decreased in March (9.40, 11.30 and 12.20 larvae / 20 bolls during 2018-19, 2019-20 and 2020-21, respectively). In 2017-18, pink bollworm incidence reached its peak in the December month (11.9 larvae / 20 bolls).

During the early stage of the cotton, pink bollworm adults emerged from diapause and laid eggs on cotton plants, but neonates die due to a lack of food source as their will not be flowers or bolls available for feeding. Hence, the larval incidence was nil where monopodia branches of cotton were more. Eventually after September, PBW larval incidence started increasing bit by bit and reached its maximum incidence during the month of February. This reveals that the highest larval incidence of pink bollworm was observed approximately four to six weeks after the peak of trap catches. However, from February onwards larval incidence was decreased. This was due to decreased. This was due to the senescent stage of the crop and meteorological parameters *viz*., increased maximum and minimum temperature.

Influence of weather factors on trap catches and larval incidence of pink bollworm

The correlation matrix and regression co-efficient indicating relationship between the pink bollworm moth catches and meteorological variables from 2017 to 2021 showed that the weekly mean pheromone trap catches of pink bollworm exerted negative association with mean of maximum temperature (r = -0.650), minimum temperature (r = -0.887), rainfall (r = -0.824), morning relative humidity (r = -0.777) and afternoon relative humidity (r = -0.824) (Table 3).

Our results are in line with the findings of Sangareddy and Patil (1997) reported that both maximum and minimum temperature had a negative influence and significantly correlated with the trap catches of pink bollworm moths. Muttappa and Patil (2019) observed negative correlation between rainfall and trap catches., also noticed that rainfall had a negative, non-significant relationship with trap catches and these finding are partially in line with our results. Indistinguishably, Shinde *et al.,* (2018) disclosed a significant negative association of trap catches with morning and afternoon relative humidity. When the data was subjected to multi linear regression analysis, the results revealed that 78.70 per cent of mean pheromone trap catches was explained by the weather parameters.

$$Y = 319.19+0.008X_1-13.193X_2-0.193X_3-0.279X_4-0.256X_5$$
$$(R^2 = 0.787)$$

The larval incidence on green bolls disclosed a negative correlation co-efficient with mean of maximum temperature (r = -0.691), minimum temperature (r = -0.963), rainfall (r = -0.668), morning relative humidity (r = -0.735) and afternoon relative humidity (r = -0.852). However, the influence of all these whether parameters was highly significant (Table 3). The multiple regression equation developed revealed that a 92 per cent variation in mean PBW larval incidence was explained by the weather parameters.

$$Y = 47.211-0.006X_1-1.964X_2-0.103X_3-0.124X_4-0.16X_5 \ (R^2 = 0.92)$$

Our findings are in line with Patil *et al.,* (2007) who

Table 2: Larval incidence of pink bollworm on green bolls during cotton growing seasons at MARS, Raichur

Month (SMW)	PBW larval incidence on green bolls in different years (Number of larvae / 20 green bolls)				
	2017-18	2018-19	2019-20	2020-21	Average
August (33rd - 35th)	5.3	0	0	0	1.33
September (36th - 39th)	6.8	0	0	0	1.70
October (40th - 44th)	8.4	3.0	0	0.8	3.05
November (45th - 48th)	11.0	7.1	6.2	13.0	9.33
December (49th - 52nd)	11.9	12.8	7.1	20.5	13.08
January (1st - 5th)	-	18.1	20.4	23.1	20.53
February (6th - 9th)	-	22.3	26.2	28.5	25.67
March (10th -13th)	-	9.4	11.3	12.2	10.97

SMW = Standard Meteorological Week - = observation not taken

Table 3: Influence of meteorological variables on PBW pheromone trap catches and larval incidence in green bolls

Parameters	Moth trap catches	Larval incidence
Maximum temperature (X_1)	-0.65**	-0.69**
Minimum temperature (X_2)	-0.89**	-0.96**
Rainfall (X_3)	-0.70**	-0.67**
Morning relative humidity (X_4)	-0.78**	-0.73**
Afternoon relative humidity (X_5)	-0.82**	-0.85**

noticed the maximum incidence in January and February months of all the four growing season (2001-02 to 2004-05) of Raichur district. However, data on the correlation between larval incidence and weather parameters are in confirmation with the fact findings of Mohapatra *et al.,* (2004) documented significant negative interdependence of larval incidence on green bolls with maximum and minimum temperature.

CONCLUSION

The study on the correlation between trap catches and larval incidence of pink bollworm, and weather parameters over a period of four years concluded that the different peak periods of PBW moth catches vary across different years. However, the peak moth catches were observed during the month of December and influenced by weather factors (mainly minimum temperature) and crop stage availability. Similarly, the incidence of pink bollworm larvae in green bolls exhibited seasonal patterns, with peak incidences observed in February and decreased incidences in March. The study identified highly significant negative correlations between trap catches and larval incidence with meteorological variables, including maximum temperature, minimum temperature, rainfall, morning relative humidity, and afternoon relative humidity. Furthermore, multiple regression analysis demonstrated that the weather parameters explained 78 to 92 per cent variation in moth trap catches and larval incidence in Bt cotton.

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