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Pheromone trap catches of pink bollworm in *Bt* and non-*Bt* cotton and their relationship to weather parameters

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Abstract
Adult trap catch of pink bollworm began in the second week of October (41st MW) (54.01 moths/trap/week) and gradually increased to its peak in the first week of November (45th MW) (144.88 moths/trap/week), but a steady maintained population of adult moths was observed up to the end of December.Trap catches in cotton had negative and non-significant relationship with minimum temperature where as, it had positive and significant relationship with maximum temperature evening relative humidity, rainfall and rainy days.The weather parameters influenced the pheromone trap catches to the extent of 73.20 per cent.

Keywords: Pink bollworm, Pheromone trap catches, *Bt* and non-*Bt* cotton, weather parameters

Introduction
Pink bollworm, *P. gossypiella* (Saunders) (Lepidoptera: Gelechiidae), is now an endemic pest of Bt cotton in both the central and southern zones of India, and is found worldwide. Eggs are laid on all tender plant parts, particularly on the bracts. PBW larvae were discovered infesting flowers after hatching, feeding on the anthers and pollens by living in a web-like structure. These flowers have a rosette shape and are twisted. Larvae bore into the bolls later, burrowing through the lint and penetrating deep into the immature seeds. When one seed is destroyed, larvae dig a tunnel through the developing lint and migrate to another seed, and so on, until they reach the locules. "Double seeds" form as a result of adjacent seeds in the boll joining together while feeding. The affected bolls rot and shed, while those that remain in the plant open prematurely, resulting in stained immature fiber with lower lint quality (Agarwal *et al*., 1984) [1]. It is known to cause 10-50 percent cotton damage. In addition to cotton, the Pink bollworm infests nearly 70 plant species, including okra and hollyhock (Noble, 1969) [2].

Material and Methods
This experiment was carried out during the kharif seasons of (2018-19) and (2019-20). In unprotected irrigated conditions, the Bt cotton hybrid Ajeet-155, which carries the Cry1Ac + Cry2Ab gene, was grown alongside AKH9916, a typical inter-specific non-Bt hybrid. To detect pink bollworm adult emergence from the first week of August to the end of December during both seasons, three pheromone sleeve traps were erected at 1-2 feet height above the plants in plots depending on crop stage. Adult male moths caught in pheromone traps were counted once every week. The data on male moth trap counts were aggregated by meteorological week and correlated to major weather parameters such as maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, rainfall, and number of rainy days. Regression analysis between trap capture and weather parameters were carried out using MS Excel.

Results and Discussion
During the first season (2018-19), the adult trap catch of pink bollworm started in August and was more or less steady until the third week of October, corresponding to the 43rd MW (58.7 moths/trap/week), after which there was a gradual increase in adult trap catches and a sudden

exert in moth emergence was observed from the first week of November, corresponding to the 44thMW (100.5 moths/trap/week). The pink bollworm population progressively declined after the second peak of moth catch was observed in the third week of December, corresponding to the 50th MW (120.8). During the following year of investigation (2019-20), a similar trend was confirmed, but the adult trap catch of pink bollworm began earlier and gradually increased, reaching its first peak in the third week of October (43rd MW) (161.38 moths/trap/week) and thereafter steadily decreased. The second peak of adult trap catch was observed in the fourth week of November (51st MW) (113.5 moths/trap/week). Pooled data analysis revealed that the adult trap catch of pink bollworm began in the second week of October (41st MW) (54.01 moths/trap/week) and gradually increased to its peak in the first week of November (45th MW) (144.88 moths/trap/week), but a steady maintained population of adult moths was observed up to the end of December.

Table 1: Pheromone trap catches during 2018-19, 2019-20 and pooled

MW	Date	2018-2019	2019-2020	Pooled
31	30 Jul - 05 Aug	0.3	0.9	0.6
32	06 Aug - 12 Aug	0.5	1.6	1.05
33	13 Aug - 19 Aug	0.7	3.75	2.225
34	20 Aug - 26 Aug	1.8	4.90	2.77
35	27 Aug - 02 Sep	6.2	7.21	6.70
36	03 Sep - 09 Sep	10.4	12.52	11.46
37	10 Sep -09 Sep	18.8	36.92	27.86
38	17 Sep - 23 Sep	34.6	52.5	43.55
39	24 Sep - 30 Sep	41.8	53.64	47.72
40	01 Oct - 07 Oct	56.9	40.25	48.57
41	08 Oct - 14 Oct	43.7	64.32	54.01
42	15 Oct - 21 Oct	37.4	110.86	74.13
43	22 Oct - 28 Oct	58.7	161.38	110.14
44	29 Oct - 04 Nov	100.5	151.35	125.92
45	05 Nov - 11 Nov	148.6	141.17	144.88
46	12 Nov - 18 Nov	143.5	108.32	125.91
47	19 Nov - 25 Nov	121.4	98.25	109.825
48	26 Nov - 02 Dec	93.8	86.4	90.1
49	03 Dec - 09 Dec	86.4	73.2	79.8
50	10 Dec - 16 Dec	120.8	10.84	111.82
51	17 Dec - 23 Dec	108.2	113.5	110.85
52	24 Dec - 31 Dec	100.9	103.8	102.35
Seasonal mean		60.72	65.34	65.10

Relationship between pheromone trap catches and weather parameters

During first year (2018 - 19) of investigation, the pheromone trap catches in cotton had negative and non-significant relationship with minimum temperature (r - 7.322), morning relative humidity (r - 0.014). Whereas, it had positive and significant relationship with maximum temperature (r = 4.568), evening relative humidity (r = 3.210), rainfall (r = 1.421) and rainy days (r = 8.163). Similar trends were observed in during year (2019 - 20). After regressing the pheromone trap catches data with all-weather parameters, the following multiple regression equation for weather parameters was obtained.

$$Y = 183.267 + 4.568X1 - 7.322X2 - 0.014X3 + 3.210X4 + 1.421X5 + 8.163X6 + 32.121$$

Where,

Y = Per cent pheromone trap catches, X1 - Maximum temperature (ºC), X2 - Maximum temperature (ºC), X3 - Morning relative humidity (%), X4 - Evening relative humidity (%), X5 – Rainfall (mm), X6 - Rainy days

This multiple regression equation indicated that, for every unit increase in minimum temperature and morning relative humidity would decrease pheromone trap catches by 7.322 and 0.014 units, respectively. Whereas, every unit increase in maximum temperature, evening relative humidity, rainfall and rainy days would increase the pheromone trap catches by 4.568, 3.210, 1.421 and 8.163 units, respectively. The weather parameters influenced the pheromome trap catches to the extent of 72.10 per cent ($R^2 = 0.721$)

The multiple linear regression for pheromone trap catches in cotton during year (2019 - 2020) was ($R^2 = 0.732$),

$$Y = -43.262 + 12.343X1 - 7.431X2 - 14.231X3 + 6.214X4 + 1.129X5 + 3.418X6 + 38.081$$

This multiple regression equation indicated that, for every unit increase in minimum temperature and morning relative humidity would decrease pheromone trap catches by 7.431 and 14.231 units, respectively. Whereas, every unit increase in maximum temperature, evening relative humidity, rainfall and rainy days would increase the pheromone trap catches by 12.343,6.214,1.129 and 3.418 units, respectively. The weather parameters influenced the pheromone trap catches to the extent of 73.20 per cent (R^2= 0.732).

These findings are consistent with the findings of the CICR annual report (CICR, 2018-19), which stated that the population of *P. gossypiella* moth in Akola ranged from 3 to 14 adults/trap/day between the 40th and 50th MW. Likewise Yalawar and Patil (2019) revealed that peak moth activity was observed during the II week of December (47th standard meteorological week) (52.78 moths/trap/night). Later on, the trap catches declined gradually with a minimum trap catch of 12.50 moths/trap/night. Similar to Amandeep *et al*. (2016) [3], the highest levels of moth collection occurred during the (41st and 43rd SMW). Likewise Shinde *et al*. (2018) [7] reported that the peak adult trap catch of pink bollworm was found in the first week of November, corresponding to the (44th SW). Similarly Ali *et al*. (2016) [4] reported that the incidence of pink bollworm began in September and was more or less steady until the second week of November corresponding to 45th SW (8.2 moths/trap), after which there was a gradual increase in adult trap catch from the third week of November corresponding to 46thSW (26.44 moths/trap) to the second week of December corresponding to 46thSW (26.44 moths/trap). These results are consistent with the findings of Yalawar and Patil (2019) stated that seasonal mean of the rosette flowers ranged from (2.25 to 15.45 percent). The infestation rates of PBW on flowers in the study areas ranged from 3.09-29.26 percent (Naik *et al*. 2021) [6]. Similarly Shinde *et al*. (2018) [7] who recorded that rosette flowers were observed from September onwards, peaking during the 45th week of November, regardless of Bt or non-Bt cotton. The number of rosette flowers gradually decreased later on. The mean percentage of rosette flowers in Bt cotton was significantly lower 3.0 percent relative to non-Bt cotton (7.2 percent), while Verma *et al*. (2017) [8] reported that the pink bollworm, *P. gossypiella*, Infestation on flowers was higher in the second week of September with an intensity of 7 larvae/30 flowers.

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