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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; SP-10(12): 420-422

www.thepharmajournal.com
Received: 07-10-2021
Accepted: 09-11-2021

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Incidence of rosette flowers by pink bollworm in Bt and non-Bt cotton and their relationship to weather parameters

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Abstract
In 2018-19 rosette flowers ranged from 1.14 to 26.12 per cent in non-*Bt* cotton and from 1.09 to 15.86 per cent in *Bt* cotton. In 2019-20, the corresponding values for non-*Bt* cotton were 1.1 to 26.15 and 1.42 to 14.24 for *Bt* cotton. Correlation studies revealed that per cent rosette flowers in 2018-19 and 2019-20 exhibited significant positive and significant negative correlation with maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, rainfall and rainy days respectively.

Keywords: pink bollworm, *Bt cotton, non-Bt cotton, weather parameters*

Introduction
All tender plant parts, especially the bracts, are used to lay eggs by adult moths. After hatching, PBW larvae were found infesting flowers, feeding on anthers and pollens while living in a web-like structure. These twisted rosette flowers have a rosette shape. Later, larvae bore into the bolls, burrowing through the lint and reaching deep into the immature seeds (Noble, 1969) [4]. When one seed is destroyed, the larvae dig a tunnel through the developing lint and migrate to the next seed, and so on until they reach the locules. When adjacent seeds in a boll join together while feeding, "double seeds" form (Agarwal *et al*., 1984) [1].

Material and Methods
This experiment was conducted during the kharif seasons of (2018-19) and (2019-20). Ajeet-155, a *Bt* cotton hybrid with the *Cry1Ac + Cry2Ab* gene, was grown alongside AKH9916, a typical inter-specific non-*Bt* hybrid, in unprotected irrigated conditions. The observations on rosette flowers attributable to pink bollworm infestation started in August and were conducted at weekly intervals until December. Per week after the initiation of flowers, twenty plants were chosen at random to count the total number of flowers and the number of rosette flowers. Finally the following formula was used to calculate the percentage of rosette flowers (Nadaf and Goud 2007) [2].

$$\text{Per cent Rosette Flowers (\%)} = \frac{\text{Number of Rosette flowers}}{\text{Total no of flowers}} \text{x100}$$

All observations are made at weekly intervals on 20 randomly chosen plants, by evading boundary rows and analyzed using the "t" test after sufficient transformation. The data on per dent rosette 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 per cent rosette flowers and weather parameters were carried out using MS Excel.

Table 1: Rosette flowers in non-*Bt* and *Bt* cotton during 2018-19, 2019-20 and pooled

MW	Duration	Rosette flowers due to PBW (%)					
		2018-19		2019-2020		Pooled	
		Non *Bt*	*Bt*	Non *Bt*	*Bt*	Non *Bt*	*Bt*
31	30 Jul – 05 Aug	-	-	-	-	-	-
32	06 Aug – 12 Aug	-	-	-	-	-	-
33	13 Aug – 19 Aug	-	-	-	-	-	-
34	20 Aug- 26 Aug	-	-	-	-	-	-
35	27 Aug – 02 Sep	1.14(1.06)	0	-	-	0.57(0.75)	-
36	03 Sep – 09 Sep	1.37(1.17)	0	1.1(1.04)	0	1.23(1.10)	-
37	10 Sep -09 Sep	2.17(1.47)	0	1.64(1.28)	0	1.905(1.38)	-
38	17 Sep – 23 Sep	4.47(2.11)	9.54(2.39)	3.64(1.90)	8.53(2.92)	4.055(2.01)	9.035(1.79)
39	24 Sep – 30 Sep	3.92(1.97)	12.13(3.54)	2.01(1.41)	10.02(3.16)	2.96(1.72)	11.075(3.12)
40	01 Oct – 07 Oct	9.87(3.14)	15.86(3.98)	6.04(2.45)	13.28(3.64)	7.95(2.81)	14.57(4.75)
41	08 Oct – 14 Oct	11.86(3.44)	13.21(3.63)	11.02(3.31)	14.24(3.77)	11.44(3.38)	13.825(3.48)
42	15 Oct – 21 Oct	14.11(3.75)	10.32(3.21)	13.63(3.69)	12.36(3.51)	13.87(3.72)	11.34(2.28)
43	22 Oct – 28 Oct	13.13(3.62)	11.02(2.70)	14.21(3.76)	11.54(3.39)	13.67(3.69)	11.28(2.75)
44	29 Oct – 04 Nov	19.05(4.36)	9.96(3.15)	15.38(3.92)	8.72(2.95)	17.21(4.14)	9.34(3.05)
45	05 Nov – 11 Nov	23.76(4.87)	9.53(2.53)	22.17(4.70)	7.03(2.65)	22.96(4.79)	8.28(3.46)
46	12 Nov – 18 Nov	25.34(5.03)	6.11(2.47	26.15(5.11)	5.16(2.27)	25.74(5.07)	5.635(2.45)
47	19 Nov – 25 Nov	26.12(5.11)	5.16(2.85)	24.18(4.91)	4.01(2.02)	25.15(5.01)	4.585(2.27)
48	26 Nov – 02 Dec	24.38(4.93)	4.45(2.53)	20.15(4.48)	3.63(1.94)	22.26(4.71)	4.04(2.07)
49	03 Dec – 09 Dec	13.35(3.65)	3.21(2.68)	14.74(3.83)	2.43(1.52)	14.04(3.74)	2.82(2.08)
50	10 Dec – 16 Dec	14.31(3.78)	2.54(2.13)	13.27(3.64)	2.02(1.16)	13.79(3.71)	2.28(1.18)
51	17 Dec – 23 Dec	12.43(3.52)	1.27(1.12)	11.37(3.37)	1.42(1.19)	11.9(3.44)	1.34(1.04)
52	24 Dec – 31 Dec	11.02(3.31)	1.09(1.04)	10.62(3.25)	1.61(1.26)	10.8(3.28)	1.35(1.05)
Mean		10.87778	7.693	12.43059	7.06	11.654185	7.376
Variance		1.913541		1.422397		2.280845	
T test		0.025571		0.020577		0.017866	
P value		<0.05		<0.05		<0.05	

Results and Discussion

The significance of the seasonal mean showed that Ajeet-155 had a lower percentage of rosette flowers (7.693 per cent) than non-*Bt* (AKH9916) (10.87 per cent) (Table.1). Pink bollworm incidence commenced in the first week of September (35th MW) in non-*Bt* cotton and in the third week of September (38th MW) in *Bt* cotton and gradually increased, reaching a peak in the third week of November (47th MW) in non-*Bt* cotton and the first week of October (40th MW) in *Bt* cotton at 26.12 and 15.86 per cent, respectively. Later on in 2018-19 season the incidence in both *Bt* and non-*Bt* cotton gradually declined. During the following year of investigation 2019-20 a similar trend was identified, but the incidence of pink bollworm was observed in the first week of September (36th MW) in non-*Bt* cotton and in the third week of September (38th MW) in *Bt* cotton and then gradually increased, reaching a peak in the second week of November (46th MW) in both non – *Bt* cotton and in the second week of October (41st MW) in *Bt* cotton as 26.15 and 14.24 per cent respectively. A pooled review of data showed that the percentage of rosette flowers on *Bt* cotton was significantly lower (7.376 per cent) than the 11.65 per cent of rosette flowers observed on non-*Bt* cotton. In non-*Bt* and *Bt* cotton hybrids, the insect peak occurrence was 25.74 and 14.57 per cent rosette flowers, at (46th MW and 40th MW) respectively. There was a steady decrease in the incidence later on.

Relationship between per cent rosette flowers 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 = -6.742), morning relative humidity (r = - 0.234). Whereas, it had positive and significant relationship with maximum temperature (r = 3.088), evening relative humidity (r = 1.010), rainfall (r = 2.671) and rainy days (r = 2.923). 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.

$$Y = 183.267 + 3.764X_1 - 7.622X_2 - 0.134X_3 + 4.050X_4 + 1.911X_5 + 6.373X_6 + 38.161$$

Where,

Y= Per cent pheromone trap catches, X_1 - Maximum temperature(ºC), X_2 - Maximum temperature(ºC), X_3 - Morning relative humidity(%), X_4 - Evening relative humidity(%), X_5 - Rainfall(mm), X_6 - 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 7.622 and 0.134 units, respectively. Whereas, every unit increase in maximum temperature, evening relative humidity, rainfall and rainy days would increase the pheromone trap catches by 3.764, 4.050, 1.911 and 6.373 units, respectively. The weather parameters influenced the pheromome trap catches to the extent of 82.90 per cent (R^2= 0.829)

The multiple linear regression for pheromone trap catches in cotton during year (2019-2020) was (R^2= 0.792),

$$Y = -43.262 + 10.563X_1 - 5.851X_2 - 5.231X_3 + 8.604X_4 + 1.429X_5 + 5.402X_6 + 38.081$$

This multiple regression equation indicated that, for every unit increase in minimum temperature and morning relative humidity would decrease pheromone trap catches by 5.851 and 5.231 units, respectively. Whereas, every unit increase in

maximum temperature, evening relative humidity, rainfall and rainy days would increase the pheromone trap catches by 10.563,8.604,1.429 and 5.402 units, respectively. The weather parameters influenced the pheromone trap catches to the extent of 79.20 per cent (R^2= 0.792).These results are consistent with the findings of Yalawar and Patil (2019) [7] who reported that seasonal mean of the rosette flowers ranged from (2.25 to 15.45 per cent). The infestation rates of PBW on flowers in the study areas ranged from 3.09–29.26 per cent (Naik *et al*. 2021) [3]. Similarly, Verma *et al*. (2017) [6] reported that the pink bollworm *P. gossypiella* infestation on flowers was higher in the second week of September with an intensity of 7 larvae per 30 flowers. Correspondingly Shinde *et al.* (2018) [5] stated that flower rosetting peaked in non-*Bt* cotton during the 46th MW whereas in *Bt* cotton peak rosette flowers were observed during the 47th MW.

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