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Effect of abiotic factors on bollworms infestation in *Bt* and Non-*Bt* cotton genotypes

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Abstract
The present field trial was conducted to establish the effect of ecological factors on the infestation of bollworms on seven varieties of genetically/non-genetically modified cotton at Research Farm of cotton section, Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar, India during the crop season 2014-15. The Bollworms squares infestation observation was started from started from 30th Standard Meterological Week (SMW) and continued till harvesting of crop (41st SMW) and it was observed, highest infestation was recorded on 39th SMW (9.2%). It 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. Correlation with abiotic factors was also calculated. It was found that bollworms infestation showed negative significant correlation (r= -0.740**) with minimum temperature and non-significant negative (r= -0.309) with maximum temperature, evening relative humidity (r= -0.434) and with rainfall (r= -0.074). They had positive correlation (r= 0.132) with morning relative humidity.

Keywords: Abiotic factors, Bollworms, *Bt* and Non-*Bt* genotype and infestation

1. Introduction
Cotton (*Gossypium hirsutum* L.,) is an important fiber crop grown in more than 80 countries. In Haryana, cotton is cultivated on 5.76 lakh hectares with production of 17 lakh bales with productivity of 502 kg/ha and our country occupies 118.81 lakh ha area with production of 352 lakh bales [2]. The crop production is hampered by many insect pests belongs to sucking and bollworms categories [1]. Among the pests, bollworm complex namely American bollworm, *Helicoverpa armigera* (Hubner); Pink bollworm *Pectinophora gossypiella* (Saunders); Spotted bollworms, *Earias insulana* (Boisduval) and *Earias vittella* (Fabricius) are the most severe pests of cotton which cause up to 50 percent loss [8]. In present, these pests are being controlled with application of broad spectrum insecticides. But the continuous use of pesticides accelerate the biotypes and hazard environment, therefore we have need an alternate method to control the pest infestation. *Bt* (*Bacillus thuringiensis*) cotton is the best option to reduce the number of insecticides sprays. *Bt* cotton has delta-endotoxin crystal protein which is harmful for larvae and work as commercial insecticide [15] with no adverse effect on natural enemies of target pests [9]. Abiotic factors also affect the bollworms infestation. Therefore, the present study was done to evaluate efficacy of different *Bt* cultivars and weather parameters on bollworms infestation on squares of cotton crop.

2. Material and methods
2.1 Bollworms infestation on squares
The present study was conducted at C.C.S., Haryana Agricultural University, Hisar, during the crop season 2014-15 in order to study the bollworms infestation on squares in cotton crop under unsprayed conditions on seven cotton genotypes procured from Private Sector and Department of Genetics & Plant Breeding. Out of seven genotypes, five were *Bt* with different gene construct (BIOSEED-6588, NECH-6, JK-1947, SP-7007 and RCH-134), and two were non *Bt* (HHH-223 and H-1236). Sowing was done on May, 2014 using standard package of practices [3] with randomized block design (RBD). Observations on bollworms infestation were recorded from the fruiting bodies of three plants from each genotype per plot. Observations were recorded at weekly intervals. It was started from 30th SMW and continued till harvesting of crop. Fruiting bodies *i.e.* squares were plucked from randomly selected three plants per replication per treatment and infestation of bollworms was recorded.

The data for the three replications were pooled and compared among different genotypes. The following formula was adopted for percent damage calculation:

$$\text{Percent square damage} = \frac{\text{No. of squares damaged}}{\text{Total number of squares formed}} \times 100$$

2.2 Correlation with weather parameters

Meteorological data was collected from the Department of Agricultural Meteorology Chaudhary Charan Singh Haryana Agricultural University, Hisar to correlate the bollworms infestation with the weather parameters.

2.3 Statistical analysis

The data recorded during the field experiment was got computed for analysis of variance using the methods of Panse and Sukhatme [17].

3. Results

3.1 Bollworms infestation in squares throughout the year

Data presented in Table 1 showed bollworms infestation on squares in different cotton genotypes. Data indicated that the irrespective of *Bt* and non-*Bt* genotypes the bollworms infestation in squares started from 30th SMW onwards and continued up to 41st SMW (July to October). It 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. On 30th SMW significantly lowest infestation was recorded in BIOSEED-6588 (0.21%) and it was followed by JK-1947 (0.38%) and SP-7007 (0.40%). Significantly higher infestation was observed in non-*Bt* genotype H-1236 which showed 3.32 percent infestation by bollworms. On 31st SMW lowest infestation was recorded in BIOSEED-6588 (0.49%) which was at par with JK-1947 (0.53%) and NECH-6 (0.72%). Significantly higher infestation was observed on non-*Bt* variety H-1236 (3.53%) and it was inferior among all genotypes.

Increase in the infestation by bollworms in squares was recorded from 33rd SMW and it was minimum in BIOSEED-6588 (0.69%). During 39th SMW minimum infestation was also observed in BIOSEED-6588 (3.42%) which was statistically on par with NECH-6 (4.22%). These were followed by JK-1947 (4.74%) and SP-7007 (6.10%) which was statistically on par with each other. Non-*Bt* hybrid HHH-223 (6.32%) and RCH-134 (7.00%) recorded maximum infestation by bollworms. Significantly highest infestation was recorded in non-*Bt* variety H-1236 (33.21%) at 39th SMW.

On the basis of mean value of all genotypes during SMW it was found that minimum infestation was recorded during 30th SMW (Fourth week of July) which was 1 percent. After that it increases continuously and reached to its peak during 39th SMW (fourth week of September) (9.29%) after that decreases and on 41st SMW, it was recorded 7.37 percent.

3.2 Bollworms infestation in different cotton genotypes

On the basis of genotypes mean value it has been observed that minimum infestation was recorded in BIOSEED-6588 (1.45%). It was followed by JK-1947 (2.14%), NECH-6 (2.24%), SP-7007 (2.76%), RCH-134 (3.32%), HHH-223 (3.87%) and H-1236 (15.18%). It showed that in *Bt* genotypes infestation was less while in non-*Bt* it has been recorded much higher than *Bt* genotypes.

3.3 Correlation with weather parameters

Weather has played important role in bollworms population fluctuations. Effect of abiotic factors on bollworms infestation in squares of cotton crop was calculated and presented in Table 2. It was found that bollworms infestation showed negative significant correlation with minimum temperature (r = -0.740). Non significant negative with maximum temperature (r = -0.309), evening relative humidity (r = -0.434) and with rainfall (r = -0.074). They had positive correlation with morning relative humidity (r = 0.132).

3.4 Regression equation

Based on regression analysis (Table 3) by taking bollworms infestation in squares (y) as a dependent variable and weather parameters (x) as independent variables following equations were fitted. The multiple regression analysis explained the relationship between bollworms infestation and weather parameter *i.e*. the amount of changes in bollworms damage per unit change in weather parameters indicated that there was significant (80%, regression equation Y1) contribution of these factors (R^2 = 0.80) for variability in infestation. Out of 80% variability in bollworms infestation due to various abiotic factors, minimum temperature and evening relative humidity (RHe) accounted for 74% variability (regression equation - Y2) and these were the most important factors affecting infestation. Out of 74% variability in squares infestation minimum temperature accounted for 63% contribution (regression equation – Y3).

4. Discussion

The current study, revealed that the incidence of bollworms on squares started from fourth week of July (30th SMW) and continue till harvesting the crop and it is supported by [Purohit *et al.* 2006; Sharma *et al.* 2004] who reported that the infestation of bollworms started from July [19, 20]. The present study also observed that infestation increased and reached to maximum in fourth week of September (39th SMW) and percent infestation of bollworms gradually declined and persisted till harvesting. Similarly, who reported that the infestation declined and persisted till harvesting. Many authors also described same result [7, 20]. Damage to squares varied significantly among *Bt* and non-*Bt* genotypes, being significantly higher in non-*Bt* genotypes and minimum in *Bt* genotypes. Minimum bollworms infestation in green fruiting bodies of *Bt* genotypes are in conformity with [Vennila *et al.* 2004] who also recorded similar observations in different *Bt* genotypes [21]. Similarly, it was observed that percent damage in squares was low in *Bt* (0.68%) as compared to non-*Bt* (4.40%) [5]. It was also reported that non-*Bt* plots attracted more bollworms infestation than *Bt* plots and there was a significant difference in the bollworms infestation among the *Bt* and non-*Bt* genotypes [14]. Similarly, Reported that transgenic *Bt* variety showed less infestation in squares as compare to non-*Bt* varieties [12]. Many others also reported same observation [16, 18, 10].

Environmental parameter plays a major role in bollworms infestation. In present study the infestation showed negative significant correlation with minimum temperature. Non significant negative correlation was observed with maximum temperature, evening relative humidity, with rainfall and positive correlation with morning relative humidity. Similarly, found that American bollworms incidence in squares showed significant negative correlation with minimum temperature and negative with evening relative humidity, wind speed and rainfall [19]. For spotted bollworms also they stated negative correlation with maximum, minimum temperature evening

relative humidity, rainfall and windspeed. It was also reported that pink bollworms incidence showed significant negative correlation with minimum temperature, negative with rainfall, wind speed, evening relative humidity and positive with morning relative humidity, which supports present findings [11]. Minimum temperature was the main contributing factor pink bollworm. It showed significant negative correlation with minimum temperature [4], which supports present finding. Similarly, others authors [6, 7, 13] recorded same results which supports present findings. In multiple regression analysis it was found that weather parameters contributes 80% variability in infestation. The prediction rate of populations of spotted bollworm and pink bollworm were 44%, and 84%, respectively [4], which supports present finding. The correlation and regression analysis clearly showed the importance of weather parameters in bollworms infestation in squares in *Bt* and non-*Bt* cotton.

Table 1: Damage by bollworms on squares basis in *Bt* and non-*Bt* cotton genotypes.

Genotypes	Percent damage by bollworms on squares basis Standard Meteorological Weeks												
	30	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**Mean**
BIOSEED-6588	0.21 (2.60)	0.49 (3.97)	0.63 (4.47)	0.69 (4.73)	0.88 (5.35)	1.01 (5.75)	1.24 (6.36)	1.00 (5.72)	1.32 (6.55)	3.42 (10.63)	3.38 (10.52)	3.17 (10.23)	1.45
NECH-6	0.72 (4.84)	0.72 (4.84)	1.14 (6.11)	0.95 (5.55)	1.29 (6.52)	1.38 (6.74)	2.85 (9.71)	3.01 (9.86)	2.41 (8.92)	4.22 (11.85)	4.71 (12.52)	3.43 (10.62)	2.24
JK-1947	0.38 (3.50)	0.53 (4.06)	0.84 (5.18)	1.03 (5.79)	1.25 (6.42)	1.31 (6.57)	2.07 (8.25)	3.30 (10.49)	2.23 (8.53)	4.74 (12.53)	4.55 (12.29)	3.40 (10.60)	2.14
SP-7007	0.40 (3.61)	0.89 (5.40)	1.30 (6.53)	1.26 (6.33)	1.50 (6.98)	1.69 (7.43)	3.18 (10.20)	3.41 (10.53)	2.76 (9.50)	6.10 (14.25)	5.67 (13.74)	4.51 (12.20)	2.76
RCH-134	0.81 (5.17)	0.97 (5.64)	1.18 (6.23)	1.17 (6.21)	2.00 (8.08)	2.76 (9.49)	3.87 (11.33)	4.43 (12.12)	5.00 (12.87)	7.00 (15.32)	6.20 (14.39)	4.88 (12.72)	3.32
HHH-223	1.17 (6.17)	1.05 (5.83)	1.51 (7.04)	1.89 (7.89)	2.44 (8.98)	4.54 (12.26)	4.89 (12.68)	5.32 (13.29)	5.87 (13.85)	6.32 (14.53)	6.00 (14.15)	5.43 (13.40)	3.87
H-1236	3.32 (10.48)	3.53 (10.83)	4.10 (11.67)	6.87 (15.16)	7.56 (15.92)	10.43 (18.78)	14.65 (22.48)	18.54 (25.48)	23.32 (28.81)	33.21 (35.16)	29.88 (33.11)	26.76 (31.12)	15.18
Mean	1.00	1.17	1.53	1.98	2.42	3.30	4.68	5.57	6.13	9.29	8.63	7.37	4.42
SE(m)±	(0.28)	(0.42)	(0.34)	(0.47)	(0.36)	(0.61)	(0.44)	(0.70)	(1.04)	(0.60)	(0.45)	(0.42)	
CD (P=0.05)	(0.87)	(1.32)	(1.07)	(1.46)	(1.12)	(1.90)	(1.38)	(2.17)	(3.25)	(1.88)	(1.40)	(1.31)	

* Figures in parentheses are angular transformed values

Table 2: Correlation of bollworms infestation with weather parameters.

Weather parameters	Correlation coefficient (r value)
	Bollworms damage
Temperature max. (ºC)	-0.309
Temperature min. (ºC)	-0.740**
Morning RH (%)	0.132
Evening RH (%)	-0.434
Rainfall (mm)	-0.074
Wind speed (Km/hr)	-0.337

**Significant at 1% level of significance

Table 3: Multiple regression analysis between bollworms infestation in squares and abiotic factors on cotton genotypes.

	Regression equations	R^2
Bollworms infestation	$Y1= 62 - 0.53 X_1 -1.45 X_2 - 0.136 X_3 + 0.147 X_4 + 0.275X_5$	0.80
	$Y2=39 - 1.54 X_2 + 0.09 X_4$	0.74
	$Y3=36 - 1.25 X_2$	0.63

X_1 = Maximum Temperature (°C), X_2 = Minimum Temperature (°C), X_3 = Morning Relative humidity (%), X_4 = Evening Relative humidity (%), X_5 = Wind speed (Km/hr)

5. Conclusion

In present study bollworms infestation remained throughout the crop season. The highest infestation of 9.29 percent was observed on 39th SMW. Infestation significantly differ among *Bt* and non-*Bt* genotypes being significantly higher in non-*Bt* and lower in *Bt.* Abiotic factors also affect the bollworms infestation. All the weather parameters had a negative correlation with infestation.

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