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Bollworms infestation in cotton genotypes on the bolls and locule basis under unsprayed condition

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Abstract
The present experiment was carried out on seven varieties of cotton under unsprayed condition. Experiment was carried out at research farm of cotton section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. Bollworms infestation was recorded at 90, 120 and 140 days after sowing and finally at harvest. At 90, 120 and 140 days after sowing significantly higher boll damage was observed on non-*Bt* variety H-1236 and minimum was recorded in BIOSEED-6588 and it was superior over all other genotypes. And at harvest time damage was recorded in open bolls and locule basis. Highest infestation in open bolls and locule basis was recorded in non-Bt genotype H-1236 and lowest was found in Bt genotype Bioseed-6588 that was (28.63%), (6.70%), (1.27%) and (0.40%) respectively. Yield was recorded highest in Bt genotypes as compared to non-Bt genotypes.

Keywords: Bollworms, Bt, Non-Bt genotype, infestation and yield

Introduction
Cotton is one of the most important cash crops of India due to agricultural as well as industrial importance. Cotton hampered by 1326 species of insects-pest from sowing to maturity in different cotton growing areas of the world and 162 species have been reported on the cotton crop in India, out of which 24 species have attained pest status [3]. Among these, the bollworm complex American bollworm; *Helicoverpa armigera* (Hubner), spotted bollworm; *Earias insulana* (Boisduval) and pink bollworm; *Pectinophora gossypiella* (Saunders) are the most important pests of cotton crop. Cotton yield is highly reduced due to attack of these bollworms. For controlling these pests a large number of insecticidal sprays were applied, which is harmful for environment and human health. The unseen residue of chemicals is continuously degraded the health of human, animals and plants. *Bt* (*Bacillus thuringiensis*) cotton is the best option to manage these bollworms and reduce the number of insecticides sprays. In *Bt* cotton toxins from a soil bacterium, *Bacillus thuringiensis* (*Bt*) are widely used for control of these insect pests from decades. Transgenic cotton, expressing the delta-endotoxin gene from the bacterium *B. thuringiensis* is a compelling answer to control cotton bollworms [11]. Although BG I cotton expressing Cry1Ac provided good control of bollworms but its replacement with BG II expressing dual genes Cry 1Ac and Cry 2Ab proteins has given the improved efficacy against bollworm complex and enhanced spectrum of activity against bollworms. Therefore the present experiment was carried out to study the effect of Bt and non-Bt cotton genotypes on bollworms infestation.

Material and Methods
The present experiment was carried out at Chaudhary Charan Singh, Haryana Agricultural University, Hisar, during the crop season 2014-2015 in order to study the bollworms damage in cotton crop. The study was carried out under unsprayed conditions on seven genotypes of cotton which were procured from Department of Genetics & Plant Breeding and Private Sector. Out of these 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 [1] with randomized block design (RBD). Observations on bollworms infestation were recorded from the bolls and locules of five plants from each genotype per plot. Bolls were plucked from randomly selected five plants per replication per treatment and infestation of bollworms was recorded.

Damage on green bolls

To record the damage on green bolls by bollworms, the bolls were examined on 90, 120, 140 DAS and finally at harvest. Total 50 bolls per treatment were plucked from the plants, brought in the laboratory for examination. Bolls were opened carefully to record the damage by any or all the three bollworms. Entry hole by the bollworms as well as wart by pink bollworm in the inner side of the rind was taken as the damaged boll. The damage was calculated by the following formulas:-

$$\text{Percent boll damage} = \frac{\text{No. of bolls damaged}}{\text{Total number of bolls}} \times 100$$

Damage on open bolls

Harvest damage was recorded in open bolls on boll basis as well as on locule basis from randomly selected five plants per replication per treatment.

(i) Damage on boll basis

Total number of open bolls from randomly selected 5 plants taken from each plot and examined critically for bollworms damage. The percent damage in the bolls was calculated by following formula:-

$$\text{Percent boll damage (Open boll basis)} = \frac{\text{No. of bolls damaged}}{\text{Total number of bolls}} \times 100$$

(ii) Damage on locule basis

To record observation of bollworms damage on locule basis, the total number of loculi of all the open bolls of five plants taken as above, counted and examined carefully for bollworms damage. Presence of holes in the septa of the locule was considered as damaged. The percent damage was calculated with the following formula:

$$\text{Percent boll damage (Locule basis)} = \frac{\text{No. of infested loculi}}{\text{Total no. of loculi}} \times 100$$

Yield of seed cotton

The yield of seed cotton was recorded on whole plot basis and later converted to q/hectare in all the sets of experiments.

Results

Bollworms damage in green bolls

The data presented in table 1 showed the significant difference for bollworms damage in *Bt* and non-*Bt* genotypes. Ninety days after sowing significantly higher boll damage (10.85%) was observed on non-*Bt* variety H-1236. This was followed by HHH-223 (3.02%) and it was statistically on par with RCH-134 (2.59%). Lowest damage 0.17 percent was recorded in BIOSEED-6588 and it was superior over all other genotypes.

At, 120 days after sowing, 22.67 percent boll damage was observed on H-1236 which was significantly higher than the rest of the treatments. It was followed by non-*Bt* hybrid HHH-223 (4.82%) and RCH-134 (4.10%) both were statistically at par. Lowest boll damage by bollworms was recorded in BIOSEED-6588 (0.68%).

Table 1: Bollworms damage in green boll basis in *Bt* and non-*Bt* cotton genotypes

Genotypes	Percent damage of bollworms on green boll basis			
	90 DAS	120 DAS	140 DAS	Mean
BIOSEED-6588	0.17 (2.36)*	0.68 (4.72)	1.02 (5.74)	0.62
NECH-6	1.18 (6.20)	2.50 (9.09)	4.60 (12.37)	2.76
JK-1947	0.92 (5.46)	1.87 (7.83)	3.35 (10.53)	2.05
SP-7007	0.59 (4.40)	1.72 (7.48)	3.10 (10.10)	1.80
RCH-134	2.59 (9.24)	4.10 (11.60)	5.38 (14.62)	4.02
HHH-223	3.02 (9.98)	4.82 (12.66)	8.53 (16.92)	5.31
H-1236	10.85 (19.17)	22.67 (28.39)	27.66 (31.67)	20.39
SE(m)±	(0.57)	(0.68)	(0.84)	
CD (P=0.05)	(1.78)	(2.13)	(2.59)	

*****Figures in parentheses are angular transformed values

At, 140 days after sowing, significantly higher boll damage by bollworms was recorded on non-*Bt* variety H-1236 (27.66%). This was followed by HHH-223 (8.53%) and RCH-134 (5.38%) and these were statistically on par with each other. Minimum boll damage was recorded in *Bt* genotype BIOSEED-6588 (1.02%) and it was significantly superior over all other genotypes. All the *Bt* genotypes of cotton showed superiority over HHH-223 and H-1236 in managing bollworms.

Overall mean of all observation also showed that Bioseed-6588 was found effective in controlling bollworms on cotton. As it showed 0.62 percent damage followed by SP-7007 (1.80%), JK-1947 (2.05%), NECH-6 (2.76%), RCH-134 (4.02%) and HHH-223 (5.31%). Highest bollworm damage was showed by H-1236 non-Bt genotype (20.39%).

Bollworms damage in open bolls

The data in the table 2 showed that significant difference in the bollworms infestation was recorded for *Bt* and non-*Bt* genotypes. On open boll basis significantly higher boll damage was observed on non-*Bt* variety H-1236 (28.63%). This was followed by *Bt* genotype HHH-223 (7.19%) and it was statistically on par with non-*Bt* variety RCH-134 (7.10%). Significantly lowest boll damage by bollworms was recorded in BIOSEED-6588 which showed 1.27 percent damage.

On locule basis significantly highest damage by bollworms was observed on non-*Bt* variety H-1236 which showed 6.70 percent locule damage and it was followed by HHH-223 with 2.36 percent damage and statistically on par with non-*Bt* hybrid RCH-134 (2.29%). Significantly lowest loculi damage was recorded in *Bt* genotype BIOSEED-6588 (0.40%).

Table 2: Bollworms Damage in *Bt* and non-*Bt* cotton genotypes at harvest

Genotypes	Percent infestation of bollworms on boll and locule basis	
	Boll basis	Locule basis
BIOSEED-6588	1.27 (6.37)*	0.40 (3.54)
NECH-6	4.20 (11.81)	1.30 (6.50)
JK-1947	2.90 (9.80)	1.13 (6.07)
SP-7007	3.23 (10.31)	1.17 (6.15)
RCH-134	7.10 (15.39)	2.29 (8.66)
HHH-223	7.19 (15.52)	2.36 (8.82)
H-1236	28.63 (32.32)	6.70 (14.98)
SE(m)±	(0.70)	(0.56)
CD (P=0.05)	(2.17)	(1.76)

***** Figures in parentheses are angular transformed values

Yield of seed cotton

The data in table 3 showed yield of seed cotton in *Bt* and non-*Bt* genotypes. Maximum seed cotton yield was realized from *Bt* genotype BIOSEED-6588 (21.17 q/ha) and it was significantly superior over all other genotypes including HHH-223 and H-1236.

Table 3: Yield of seed cotton in *Bt* and non-*Bt* cotton genotypes during *kharif* 2014

Genotypes	Mean yield of seed cotton (q/ha)
BIOSEED-6588	21.17
NECH-6	15.59
JK-1947	18.81
SP-7007	19.14
RCH-134	13.95
HHH-223	12.03
H-1236	10.37
SE(m)±	0.28
CD (P=0.05)	0.88
CV	10.81

It was followed by SP-7007 (19.14 q/ha). Minimum yield of seed cotton was obtained from non-*Bt* variety H-1236 (10.37 q/ha) and it was followed by non-*Bt* hybrid HHH-223 (12.03 q/ha) and RCH-134 (13.95 q/ha). Significantly higher yield of seed cotton was realized from JK-1947 (18.81 q/ha) and NECH-6 (15.59 q/ha) than the varieties H-1236 and hybrid HHH-223.

Discussion

Bollworms infestation in green bolls

Present findings indicated that the infestation of bollworms on green bolls was less among *Bt* genotypes as compared to non-*Bt* genotypes. Maximum infestation on green bolls was done by bollworms on non-*Bt* genotypes. Results are in conformity with Muhammad *et al*. [12] who reported that *Bt* genotypes (IRFH-901with 2.38%) showed minimum infestation on green bolls as compared to non-*Bt* (FH-901 with 10.76%) genotype. The present finding are similar to many authors [10, 17] who reported that *Bt* hybrids suffered significantly lower damage than their non-*Bt* counterparts providing the overall efficacy of *Bt* cotton hybrids against bollworms including pink bollworm.

Similarly, it was observed that total percent damage to fruiting bodies was low in *Bt* genotypes compared to non-*Bt* genotypes [4]. Present results are in agreement with authors [16] who reported that in *Bt* green boll damage was significantly lower compared to non-*Bt* cotton. Green boll damage 1.7 and 10.5 percent was observed in *Bt* and non-*Bt* cotton, respectively by pink bollworm [8] which supports the present findings. Similarly, it was reported that transgenic *Bt* variety IRCIM-448 showed less infestation in green bolls by bollworms with 2.44 percent as compare to non- *Bt* variety CIM-448 which showed 8.48 percent infestation [9]. These findings support the present investigation as the broadly the results are in conformity with the work of predecessor.

Bollworms infestation in open bolls

Present study indicated that the bollworms infestation in open bolls (boll and locule basis) was very low in *Bt* genotypes as compared to non-*Bt* genotypes, being higher in non-*Bt*. Present findings are in agreement, who reported that *Bt* hybrid had less boll and locule damage (%) as compared to their non-*Bt* counter parts and checks [2]. It was reported that the *Bt* hybrids had significantly lesser locule damage than their counterparts providing the overall efficiency of *Bt* cotton hybrids against bollworms [17]. The results of the present study are similar to the findings that RCH-368 *Bt* recorded lowest boll damage of 4.25 percent while non- *Bt* recorded maximum damage of 35.96 percent [5].

Yield of seed cotton in different *Bt* and non-*Bt* genotypes

The results of the present study revealed that maximum seed cotton yield was obtained in *Bt* genotypes as compare to non-*Bt* genotypes. *Bt* genotypes were significantly superior over non-*Bt* genotypes in yield. Among *Bt* genotypes yield was obtained 21.17 q/ha, while in non-*Bt* H-1236 genotype 10.37 q/ha. Present findings got support by author [6] who reported significantly higher yield of seed cotton of *Bt* genotypes. It was also reported that seed cotton yield was highest for *Bt* MECH-162 as compared to conventional cultivar [4]. Many authors also reported that maximum yield was obtained in Bt as compared to non-Bt genotypes, which supports present finding [7, 13, 14, 15].

Conclusion

In present experiment bollworms infestation was recorded at 90, 120, 140 DAS and finally at harvest. It was recorded that bollworms damage in green bolls, open bolls and in locules was minimum in Bt cotton genotypes and highest in non-Bt genotypes.

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