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RESEARCH PAPER

Incidence pattern of pink bollworm, *Pectinophora gossypiella* (Saund.) on different event *Bt* and non-*Bt* cottons

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Abstract: A field experiment was conducted at the Agricultural Research Station, Dharwad Farm, Dharwad, Karnataka during 2018-19 to evaluate the performance of cultivated cotton genotypes including *Bt* and non-*Bt* against pink bollworm, *Pectinophora gossypiella* (Saund.) under rainfed conditions. Based on seasonal mean green boll damage, Everest (13.56%) performed better against pink bollworm over single gene BG-I *Bt* variety PAU *Bt*-1 (16.55%), BG-I *Bt* hybrid MRC 6918 (25.88%) (Both expressing *Cry*1Ac) and Arjun-21 *Cry*1A) and BG-II hybrid MRC 7918 (15.52%).DCH-32 (Non *Bt* interspecific hybrid) had maximum infestation of 37.59 per cent followed by H×H hybrid DHH-263 (36.34%), Suvin (21.38%), DDhc-11 (21.59%), Sahana (20.21%) and DLSa-17 (18.65%). The maximum larval recovery was 12.66 per 20 green bolls in DCH-32 followed by DHH-263 (12.58) and Suvin (11.12). In general, Non-*Bt* genotypes had higher incidence than *Bt* genotypes. Similarly, among *Bt* toxin, *Cry*1Ac and *Cry*2Ab expressing genotype had lower incidence.

Key words: *Bt* cotton, *Cry* toxin, Event, *Pectinophora gossypiella*, Pink bollworm

Introduction

The micro-lepidopteran (Family: Gelechiidae) pest pink bollworm (PBW) *Pectinophora gossypiella* (Saunders) is the world's largest cotton pest which caused the largest drop (20-40%) in cotton seed yield (Amin and Gergis, 2006). It causes locule damage of 37.5 per cent and 13.58 per cent on non-*Bt* and *Bt* cotton, respectively, at 160 days of planting resulting into heavy loss in cotton production (Naik *et al.,* 2014). However, reports of Ingole *et al.* (2019) and Shinde *et al.* (2018) have indicated the significance of PBW in cotton cultivation in India during recent past. In January 2010, Monsanto Pvt Ltd recorded the survival of pink bollworm larvae in Bollgard-I (*Cry*1Ac) and not in Bollgard-II (*Cry*1Ac + *Cry*2Ab) in the Gujarat region of Saurashtra. Studies undertaken by ICAR-CICR (Central Institute for Cotton Research) Nagpur between 2012 and 2014 clearly showed resistance to two *Cry* toxins deployed in Bollgard-II.

Studies in 2014 obviously showed that pink bollworm larvae could survive inside bolls of genuine BG-II hybrids. About 40-80 per cent of the bolls harboured remaining larvae. Resistance surveillance could show that pink bollworms developed resistance to *Cry*1Ac, *Cry*2Ab and *Cry*1Ac+*Cry*2Ab in Amreli and Bhavnagar districts of Gujarat. Further, there was widespread survival of PBW in majority of BG-II cotton hybrids grown in Maharashtra, Telangana, Andhra Pradesh and Karnataka states during 2015 season (Kranthi, 2015).

One of the causes for resistance development in PBW is said to be mostly non-compliance of refugia, poor expression of toxin in seeds and flowers and hybrid format delivery of *Bt* toxins. In such instance the bio-ecological status of pink bollworm which has experienced more than15 years of selection pressure from *Bt* toxins has to be known to develop suitable management strategies. Since, India is the only country growing all cultivated species of cotton it is essential to know incident pattern of PBW in all species and *Bt* events properly to structure refugia appropriately.

Material and methods

The experiment was carried out at the Agriculture Research Station, Dharwad (Hebballi) farm, Dharwad, Karnataka during 2018-2019. The experiment was laid out in Randomized Complete Block Design with three replications. The plot size was 5.4 × 5.4 m^2. The space between treatments was 0.9 m and replications were placed 1.20 m apart. Each treatment plot accommodated six rows with 10 plants per row and a total of 60 plants per treatment. The treatment details are as given in the Table 1. The crop was raised with standard agronomical practices as

Table 1. Details of different cotton genotypes subjected for pink bollworm field incidence studies

Genotypes	Event / cultivar	Transgene (Bt toxins)
PAU *Bt*-1-1	BG-I *G. hirsutum* variety (Mon 531)	*Cry*1Ac
Everest	BG-II H × H hybrid (Mon 15985)	*Cry*1Ac+*Cry*2Ab
MRC 7918	BG-II H × B hybrid (Mon 15985)	*Cry*1Ac+*Cry*2Ab
DCH-32	Non-*Bt* H × B hybrid	-
DHH-263	Non-*Bt* H × H hybrid	-
DDhc-11	Non-*Bt* *G.herbaceum* variety	-
DLSa-17	Non-*Bt* *G.arboretum* variety	-
Sahana	Non-*Bt* *G.hirsutum* variety	-
Suvin	Non-*Bt* *G.barbadense* variety	-
Arjun 21	H × H hybrid (GMF fusion)	*Cry*1A
MRC 6918	BG-I H × B hybrid (Mon 531)	*Cry*1Ac

proposed by the package of practice of UAS, Dharwad except for the plant protection measure against bollworms.

For assessing the comparative performance of these *Bt* and non-*Bt* cotton genotypes season long observations were made on pink bollworm incidence at weekly intervals from square formation till harvest. The observations for typical damage due to pink bollworm larval incidence in different fruiting bodies were made on randomly selected 10 plants per genotype avoiding border row plants.

$$\text{Damaged squares (\%)} = \frac{\text{Number of damaged squares}}{\text{Total number of squares}} \times 100$$

$$\text{Rosette flowers (\%)} = \frac{\text{Number of rosette flowers}}{\text{Total number of flowers}} \times 100$$

$$\text{Green boll damage (\%)} = \frac{\text{Number of green bolls having PBW}}{\text{Total number of green bolls}} \times 100$$

$$\text{Locule damage (\%)} = \frac{\text{Number of damaged locules}}{\text{Total number of locules}} \times 100$$

The data were averaged into respective parameter requisites and subjected to suitable transformation. After proper analysis, data were accommodated in the tables as per the needs of objectives for interpretation of results. The data in numbers were transformed to $\sqrt{x + 0.5}$ values and subjected to one-way ANOVA. Statistical differences among the means were assessed by DMRT P=0.05. Computer software packages EXCEL and MSTAT C were used for analysis.

Results and discussion

By the observations of square damage (Table 2), PAU-Bt-1 proved to be significantly superior over other BG-I genotypes, BG-II hybrids and GMF event hybrid with lowest mean square damage of 1.78 per cent. Followed by MRC 7918 (2.07%) and Everest (2.18%) which were on par with each other, Arjun-21 (3.03%) was superior over MRC-6918 (BG-I). However, MRC-6918 has shown maximum of 9.47 per cent damaged squares among the *Bt* genotypes. The non-*Bt* genotypes of cotton DCH 32 (13.81%) and DHH-263 (13.26%) have shown highest square damage. In *desi* cottons genotypes the lowest damage recorded in DLSa-17 (3.71%) followed by DDhc-11 (4.00%), Sahana (9.51 %) where as Suvin recorded 10.21 per cent square damage. The results are supported by [Dhaka and Pareek (2008) and Sharma *et al.* (2004)] who stated the incidence of bollworm on squares varied significantly within the genotypes throughout the season. The present results are in conformity with Rawal *et al.* (2017) who evaluated different *Bt* genotypes and the damaged squares due to bollworms were found to be BIOSEED-6588 (1.45%), NECH (2.24%), JK-1947 (2.14%), SP-7007 (2.76%), RCH-134 (3.32 %) and non-*Bt* cotton genotypes *viz.,* HHH-223 (3.87%) and H-1236 (15.1%). It was also reported that the non-Bt plots attract more bollworms than the *Bt* genotypes, this might have been the reason for the difference in damage of squares (Kumar *et al.,* 2004 and Kamran and Stanley, 2008).

Flower rosetting as observed showed PAU *Bt*-1 (Fig. 1) with mean flower damage of 7.36 per cent followed by Everest (8.58%) and Arjun-21 (8.97%), MRC 7918 (9.31%), MRC-6918 (15.41%). On the contrary, non-*Bt* cottons DCH-32 (15.60%) and DHH-263 (15.50%) recorded highest number of mean rosetted flowers followed by Suvin (11.19%), Sahana (10.23%), DDhc-11 (9.99%), DLSa-17 (9.35%) and MRC-7918 (9.31%) which were on par with each other. Thus, like square damage, MRC-6918 Bt could sustain flower damage more than ETL of 10 per cent by September 30th itself as evident in Table 2. By October 7th DCH-32 and DHH-263 hybrids had flower damage above ETL. In desi cotton genotypes, flower damage crossed ETL by 28th October.

It was evident from the data (Table 2) that Everest BG-II

Table 2. Seasonal incidence of pink bollworm on different *Bt* and non-*Bt* cotton genotypes

Genotypes	*Square damage (%)	*Flower damage (%)	*Green boll damage (%)	**No. of larvae in 20 random bolls (%)	*Locule damage (%)
PAU *Bt*-1 (BG-I)	1.78(7.67)[i]	7.36(15.73)[e]	16.55(24.00)[g]	3.84(2.08)[e]	13.91(21.89)[d]
Everest BG-II	2.18(8.49)[h]	8.58(17.03)[d]	13.56(21.60)[i]	4.22(2.17)[e]	9.49(17.94)[f]
MRC 7918 BG-II	2.07(8.26)[h]	9.31(17.76)[cd]	15.52(23.20)[h]	3.57(2.02)[e]	12.08(20.33)[e]
DCH-32	13.81(21.80)[a]	15.60(23.25)[a]	37.59(37.80)[a]	12.66(3.63)[a]	34.25(35.80)[a]
DHH-263	13.26(21.34)[b]	15.50(23.18)[a]	36.34(37.06)[b]	12.58(3.62)[a]	29.70(33.01)[b]
DDhc-11	4.00(11.54)[e]	9.99 (18.42)[cd]	21.59(27.68)[d]	8.35(2.98)[c]	22.19(28.09)[c]
DLSa-17	3.71(11.09)[f]	9.35(17.80)[cd]	18.65(25.57)[f]	9.83(3.21)[b]	22.30(28.17)[c]
Sahana	9.51(17.96)[d]	10.23(18.65)[cd]	20.21(26.71)[e]	10.05(3.25)[b]	21.87(27.87)[c]
Suvin	10.21(18.63)[c]	11.19(19.53)[b]	21.38(27.53)[d]	11.12(3.41)[b]	22.89(28.57)[c]
Arjun-21 GFM Bt	3.03(10.01)[g]	8.97(17.42)[d]	15.27(22.99)[h]	7.73(2.87)[d]	12.24(20.47)[e]
MRC 6918 BG-I Bt	9.47(17.92)[d]	15.41(23.11)[a]	25.88(30.57)[c]	8.56(2.80)[c]	28.30(32.13)[b]
S.Em.±	6.64	0.209	0.13	0.13	0.37
C.V. (%)	0.213	11.621	3.27	5.75	7.78

Means followed by similar alphabets in the vertical columns do not differ significantly at 0.05% by DMRT

*Figures in the parentheses are arc sin transformed values

**Figures in the parentheses are $\sqrt{x+0.5}$ transformed values

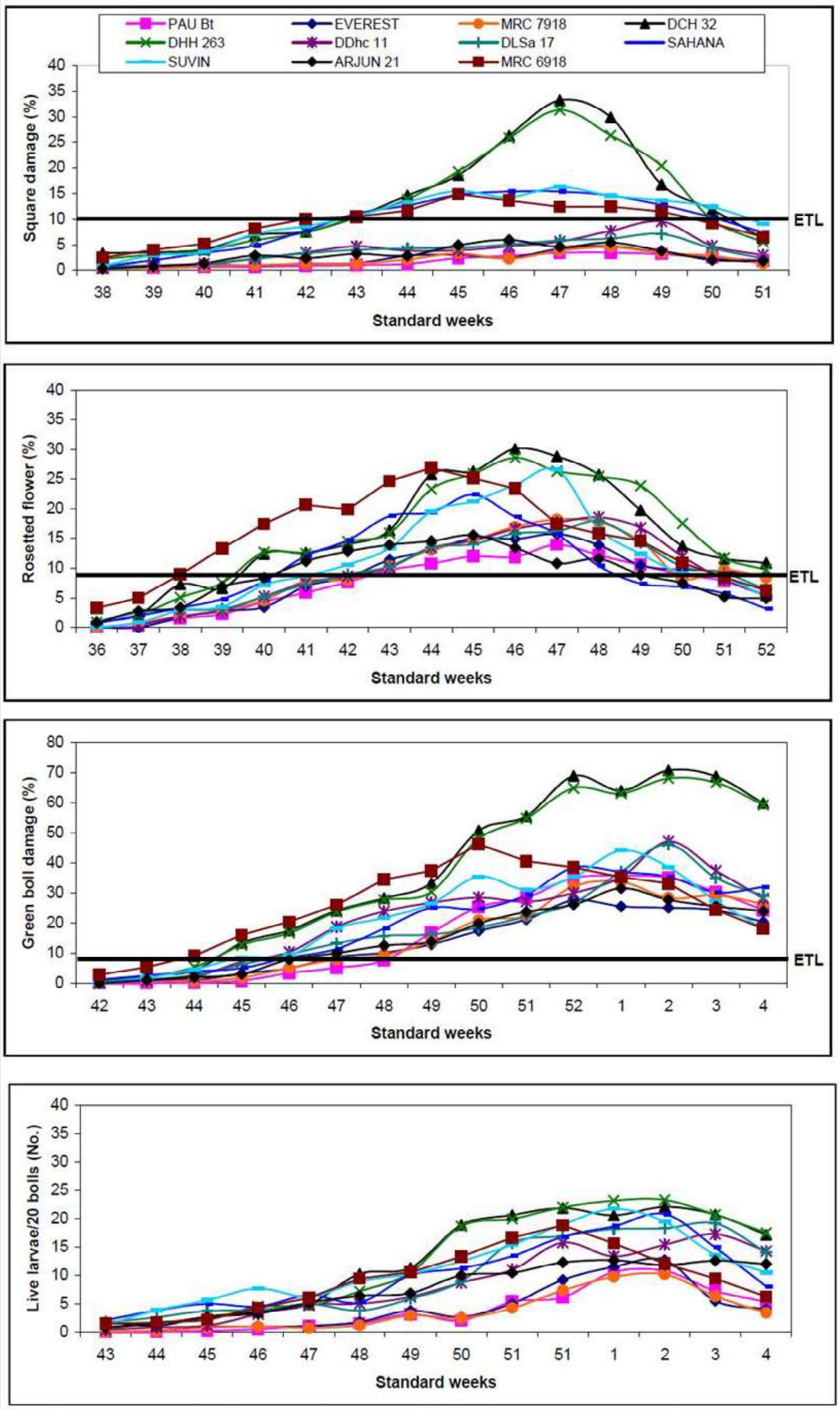

Fig. 1: Fruiting body damage in different Bt and non-Bt cotton genotypes and larval recovery

(13.56%) had significantly least damaged green bolls among all genotypes tested. Followed by MRC-7918 (15.52%) and Arjun-21 (15.2%) being on par with each other, PAU *Bt*-1 (16.55%), MRC-6918 (25.88%). In non-*Bt* genotypes significantly highest per cent of green boll damage was noticed in case of DCH-32 (37.59%) followed by DHH-263 (36.34%), DDhc-11 (21.59%), Suvin (21.38%), Sahana (20.21%) and DSLa-17(18.65%)recorded significantly lowest green boll damage.

The lowest of 3.57, 3.84 and 4.22 larvae in 20 bolls were noticed in MRC-7918, PAU Bt-1and Everest, respectively which were on par with each other. The next significantly lower population were noticed in MRC-6918 (8.56 larvae/20 bolls) and Arjun-21 (7.73 larvae/20 bolls). The highest population of 12.66 and 12.58 larvae in 20 green bolls was observed in DCH-32 and DHH-263 both being statistically on par amongst. Further, 11.12, 10.05 and 9.83 larvae were observed from green bolls of Suvin, Sahana and DLSa-17, respectively which were also on par with each other. Thus, pink bollworm live larval recovery was highest in non-*Bt* H x H or H x B hybrids followed MRC-6918 *Bt* and then *desi* genotypes.

The present findings are in accordance with Santosh *et al* (2009) Marchosky *et al.* (2001) who reported that the BG-I and BG-II hybrids had consistently fewer PBW larvae.

There was significantly lowest locule damage in case of Everest (9.49 %) followed by 12.08 and 12.24 per cent in MRC-7918 and Arjun-21, respectively. The highest of damage 34.25 was noticed in case of conventional hybrid DCH-32 followed by 29.70 and 28.30 per cent in DHH-263 and MRC-6918, respectively. In other conventional cottons 21.87, 22.30 and 22.89 per cent of damaged locule were noticed in Sahana, DLSa-17 and Suvin, respectively.

The comparative seed cotton yield levels of all the *Bt* events (Fig. 2) indicated that intra specific BG-II hybrid Everest and the fusion gene event Arjun-21 have excelled over others by producing significantly high seed cotton yield and also good kapas than any other events. Everest has yielded 7.46 q/ha followed and Arjun-21 (6.85 q/ha) of good kapas both being statistically on par with each other. This was followed by MRC-6918, MRC-7918 and PAU Bt-1 which were on par with each other with 6.03, 5.96 and 5.62 q/ha of good kapas,

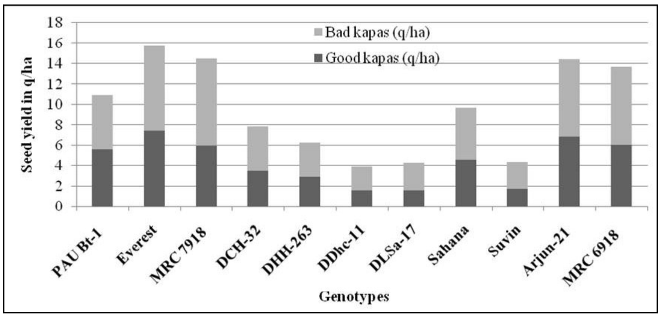

Fig 2. Seed cotton yield and damaged kapas portion as influenced by pink bollworm incidence

respectively. In non-*Bt* genotypes yield was significantly lower (Fig. 2) than *Bt* events. Sahana could yield 4.61q/ha good kapas followed DCH-32 and DHH-263 yielding 3.51 and 2.90 q/ha, respectively. The lowest seed cotton yield was observed in Suvin, DLSa-17 and DDhc-11 which could yield 1.73, 1.62 and 1.58 q/ha of good kapas, all being on par with each other. These results are in accordance with Bhosle *et al.* (2004) who reported the locule damage due to pink bollworm was 9.14 to 10.54 per cent in *Bt* cotton, while it was 17.61 to 19.66 per cent in conventional hybrids. Hareesha *et al.* (2011) reported that BG-II genotypes recorded the locule damage ranging from 9.67 to 11.33 per cent being superior over BG-I hybrids and DCH-32 recorded 47.33 per cent of locule damage. Onkaramurthy *et al.* (2016) also confirmed the superiority of BG-II over BG-I hybrids stating the BG-II hybrids were on par with each other in recording the locule damage. The BG-I was inferior to BG-II but superior over conventional cottons in checking bollworm *H. zea*, beet armyworm and fall armyworm (Chitkowski *et al*., 2003) however it failed to check pink bollworm in the present study. Similar results were documented by Jeushale *et al.* (2007). Hence development and adaption of IPM strategies are essential to manage pink bollworm in *Bt* cottons.

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