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RESEARCH PAPER

Comparative efficacy of different cotton hybrids containing Bt genes against *Pectinophora gossypiella* (Saunders)

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Abstract: Field experiment was conducted at Agricultural Research Station, Dharwad farm, during 2018 and 2019 to evaluate performance of eighteen different cotton genotypes representing four different *Bt* events. Damage due to pink boll worm (PBW) was least in intraspecific (H×H) hybrids compared to interspecific hybrids (H×B) hybrids. Cotton hybrid Everest recorded least flower damage of 9.40 per cent, followed by Jadoo (9.71%) and were on par. The highest per cent flower damage of 22.57 was registered in (H × H) non *Bt* hybrid DCH-32. Least boll damage of 13.93 per cent was recorded in Everest BG-II and was on par with Jadoo (14.94%) and highest per cent boll damage of 41.26 was recorded in DCH-32 The seed cotton yield was highest in Everest BG-II (15.20 q/ha). Among BG-I genotypes, VCH-5 (Event-1) recorded highest yield (9.84 q/ha) and the least yield was recorded in DCH-32(5.97 q/ha).

Key words: Bollworm,Cotton hybrids, *Genotype, Pectinophora gossypiella*

Introduction

Cotton (*Gossypium* spp.) belongs to the family Malvaceae is a major commercial crop grown in 111 countries. China, India and the United States are the leading cotton-producing countries. India cultivates more than 11 million hectares annually and has the largest area in the world. The exact area under *Bt* cotton in 2019 is 12.58 mha with production of 360.00 lakh bales and yield accounting to 486 kg/ha (Anon, 2020). The three bollworms, American bollworm *Helicoverpa armigera* (Hubner) Hardwick, Pink bollworm (PBW) *Pectinophora gossypiella* Saunders and the Spotted bollworms- *Eariasvittella* (Fabricius) and *Eariasinsulana* (Boisduval) are the major pests and cause serious threat to cotton production resulting in significant yield losses (Agarwal and Katiyar, 1979).

The pink bollworm *Pectinophora gossypiella,*was described by W.W. Saunders in 1843 as *Depressaria gossypiella* from specimens found to damaging cotton in India. It is a stenophagous pest which has coevolved with malvaceous food plants like cotton, okra, deccan hemp and roselle (Anon, 2017). At present, the pink bollworm has been recorded in nearly all cotton-growing countries of the world and is a key pest in many of these areas. Unlike present situation approximately 40,672 t of pesticides were sprayed on cotton crop prior to the actual implementation of *Bt* cotton, these insecticides were mainly aimed at the bollworms species (Bambawale *et al.* 2004; Dhaliwal and Arora, 2003). This caused widespread ecological disruption leading to exacerbation of bollworm and secondary pest problems in cotton ecosystem (Kranthi *et al.* 2002; Kranthi and Russell 2009; ICAC 2010). James (2014) reported that *Bt* cotton cultivation has significantly reduced insecticide use, increased productivity and improved environmental quality. Impact of Cry 1 Ac Bt toxin was quite good in suppressing PBW infection in interspecific Bt cotton hybrid also (Santhosh *et al*., 2009) initially. Field evolved resistance to *Bt* cotton has been reported in pink bollworm, *Pectinophora gossypiella* to Cry1Ac in India in 2008 (Dhurua and Gujar, 2011). Expression of Cry2Ab in Bollgard®- II is reported to be 10 to 100 fold more as compared to Cry1Ac (Knight *et al*., 2013) which render the pink bollworm under more selection pressure of Cry2Ab. The suppression of bollworms is a great success in India until the survival reports of pink bollworm during 2009. In recent years, severe damage to bolls by pink bollworm and yield-losses were observed in *Bt*-cotton in many regions of Gujarat and some parts of AP, Telangana and Maharashtra (Kranthi, 2015). Thus further study was carried to assess the efficacyof various Bt cotton hybrids grown in Karnataka aginst pink bollworm incidence.

Material and methods

The experiment included fifteen *Bt* and three non-*Bt* cotton genotypes representing all cultivated species of cotton and

Table 1. Different popular *Bt* and non *Bt* cotton genotypes

Treatments	Genotypes (trade name)	Type of genotype	Transgenic event
T_1	Bindas	H×H	BG-II
T_2	President gold	H×H	BG-II
T_3	Jadoo	H×H	BG-II
T_4	Everest	H×H	BG-II
T_5	First class	H×H	BG-II
T_6	ATM	H×H	BG-II
T_7	MRC-7351	H×H	BG-II
T_8	MRC-7353	H×H	BG-II
T_9	MRC-7918	H×B	BG-II
T_{10}	Puli	H×B	BG-II
T_{11}	Sowmya	H×B	BG-II
T_{12}	VCH-5	H×H	BG-I
T_{13}	MRC-6918	H×B	BG-I
T_{14}	Arjun-21	GMF	GMF
T_{15}	Profit +	GMF	GMF
T_{16}	DCH-32	H×B	Non *Bt*
T_{17}	DHH-263	H×H	Non *Bt*
T_{18}	Sahana	-	Non *Bt*

different *Bt* events as well at ARS Hebballi Farm, Dharwad. The treatment details are as given in the (Table 1). The crop was raised by following the production practices recommended by UAS Dharwad, except for the plant protection measures against bollworms.

Design and layout

The experiment was laid out in Randomized Complete Block Design with three replications. The plot size was 5.4 × 5.4 m^2 with spacing of 90 × 60 cm. Each plot accommodated six rows with 10 plants/ row and a total of 60 plants per treatment.

Sowing, crop maintenance and harvest

The sowing was done on June 16th, 2018 and July 23rd in 2019 in deep black cotton soils by dibbling with intra row spacing of 60 cm and inter-row spacing of 90 cm. In each plot 60 plants were maintained with gap filling and thinning after a week of germination. The fertilizer application was at the rate of 100:50:50 Kg of NPK/ha in the form of Urea, DAP and MOP with two splits of N, at sowing and at 40 DAS. Crop was kept weed free through regular intercultural operations and hand weeding. The crop was protected from sucking pests by spraying Acetamiprid 20 SP 0.15 g/l at 30 and 60 DAS, respectively during both the years. Harvesting of seed cotton was done as a single picking after allowing complete boll bearing and bursting to tap maximum genetic potentiality.

Data collection

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 for flower and green boll damage till the harvest and were computed by suitable formulae.

Table 2. Rosetted flowers damage due to pink bollworm in different *Bt* and non *Bt* cotton genotypes Pooled

Genotypes	Transgenic event	Per cent rosetted flower damage						
		60 DAS	75 DAS	90 DAS	110 DAS	135 DAS	150 DAS	Mean
Bindas (H×H)	BG- II	1.77 (7.63)^{op}	11.79 (20.08)^{k}	16.08 (23.64)^{op}	14.44 (22.33)^{pq}	10.16 (18.59)^{pq}	5.60 (13.68)^{op}	9.97 (18.41)^{op}
President gold (H×H)	BG- II	3.83 (11.29)^{hi}	10.68 (19.07)^{no}	20.76 (27.11)^{mn}	18.63 (25.57)^{de}	12.48 (20.69)^{mn}	8.20 (16.64)^{fg}	12.43 (20.64)^{jk}
Jadoo (H×H)	BG-II	1.85 (7.81)^{no}	11.44 (19.77)^{kl}	15.80 (23.42)^{pq}	13.98 (21.95)^{qr}	9.93 (18.37)^{qr}	5.22 (13.2)^{pq}	9.71 (18.15)^{pq}
Everest (H×H)	BG- II	1.91 (7.93)^{mn}	7.88 (16.30)^{r}	14.25 (22.18)^{qr}	17.25 (24.54)^{lm}	10.83 (19.21)^{op}	4.31 (11.98)^{qr}	9.40 (17.86)^{qr}
First class (H×H)	BG- II	1.94 (8.01)^{lm}	11.08 (19.44)^{mn}	19.34 (26.09)^{no}	17.57 (24.78)^{hi}	11.31 (19.65)^{no}	6.8 (15.11)^{no}	11.34 (19.68)^{no}
ATM (H×H)	BG-II	0.77 (5.03)^{qr}	10.11 (18.53)^{pq}	20.85 (27.17)^{lm}	15.94 (23.53)^{op}	12.95 (21.09)^{kl}	7.41 (15.80)^{kl}	11.34 (19.68)^{mn}
MRC-7351 (H×H)	BG-II	0.88 (5.37)^{q}	11.30 (19.64)^{lm}	21.20 (27.41)^{kl}	16.12 (23.67)^{no}	12.89 (21.04)^{lm}	7.13 (15.49)^{mn}	11.59 (19.9)^{lm}
MRC-7353 (H×H)	BG-II	2.23 (8.59)^{l}	10.22 (18.64)^{op}	21.67 (27.74)^{ij}	18.34 (25.35)^{ef}	13.74 (21.76)^{jk}	7.48 (15.87)^{jk}	12.28 (20.51)^{kl}
MRC-7918 (H×B)	BG-II	4.55 (12.31)^{ef}	15.21 (22.95)^{ef}	23.19 (28.78)^{ef}	17.98 (25.09)^{gh}	16.38 (23.87)^{bc}	9.51 (17.96)^{cd}	14.50 (22.39)^{ef}
Puli (H×B)	BG-II	3.86 (11.32)^{gh}	13.95 (21.93)^{ij}	21.30 (27.48)^{jk}	17.48 (24.71)^{jk}	15.20 (22.95)^{gh}	8.81 (17.27)^{ef}	13.51 (21.56)^{gh}
Sowmya (H×B)	BG-II	4.32 (12.01)^{fg}	14.27 (22.19)^{hi}	22.59 (28.38)^{fg}	17.52 (24.74)^{ij}	15.31 (23.03)^{fg}	8.92 (17.37)^{de}	13.74 (21.76)^{fg}
VCH-5 (H×H)	BG-I	4.80 (12.66)^{de}	17.13 (24.45)^{cd}	23.51 (29.00)^{de}	18.31 (25.33)^{fg}	16.34 (23.84)^{cd}	8.14 (16.57)^{gh}	14.56 (22.43)^{de}
MRC-6918 (H×B)	BG-I	4.91 (12.80)^{d}	16.53 (23.99)^{de}	23.90 (29.26)^{d}	21.17 (27.39)^{cd}	17.25 (24.54)^{ab}	9.57 (18.02)^{bc}	15.65 (23.3)^{cd}
Arjun-21	GMF	3.82 (11.26)^{ij}	14.99 (22.78)^{fg}	22.20 (28.11)^{gh}	17.25 (24.54)^{kl}	15.04 (22.81)^{hi}	7.82 (16.23)^{hi}	13.42 (21.49)^{hi}
Profit+	GMF	3.54 (10.84)^{jk}	14.40 (22.30)^{gh}	21.70 (27.76)^{hi}	16.53 (23.99)^{mn}	14.81 (22.63)^{ij}	7.56 (15.96)^{ij}	13.19 (21.29)^{ij}
DCH-32 (H×B)	Non *Bt*	11.50 (19.82)^{a}	23.32 (28.88)^{a}	37.80 (37.94)^{a}	30.47 (33.50)^{a}	18.72 (25.63)^{a}	13.64 (21.67)^{a}	22.57 (28.37)^{a}
DHH-263 (H×H)	Non *Bt*	9.24 (17.70)^{b}	21.12 (27.36)^{b}	35.09 (36.32)^{ab}	27.49 (31.62)^{ab}	16.05 (23.61)^{de}	10.03 (18.46)^{b}	19.83 (26.45)^{ab}
Sahana	Non *Bt*	7.01 (15.35)^{c}	18.08 (25.16)^{c}	32.62 (34.83)^{bc}	25.55 (30.36)^{bc}	15.39 (23.09)^{ef}	7.28 (15.65)^{lm}	17.65 (24.84)^{bc}
S.Em(±)		0.56	0.42	1.10	1.23	1.04	0.91	0.95
C. D (p=0.05)		1.62	1.26	3.36	3.72	3.10	2.6	2.86
C. V (%)		10.93	10.93	10.45	9.29	9.25	10.12	10.14

* Figures in the parentheses are arcsine transformed values, Mean followed by the same alphabet in a column do not differ significantly (P=0.05) by DMRT, DAS: Days After Sowing

The seed cotton was harvested from every plant except border rows. The kapas yield per plot was converted into quintal per ha. The kapas was stratified as good and bad kapas.

The data generated on flower rosetting and green boll were transformed to arc sine values and then were subjected to one way ANOVA using MSTATC® software package and treatments performance were compared through DMRT.

Results and discussion

Flower damage

The data on flower damage indicated the significant differences among the treatments at all growth point starting from 60 to 150 DAS (Table 2). The highest flower damage was noticed at 90 DAS observation in all genotypes and declined thereafter. However, flower damage was least in Everest and Jadoo hybrids with 9.40 and 9.71 per cent respectively and were on par with each other. Among the BG-I hybrids, MRC-6918 (H × B) and VCH-5 (H × H) were recorded highest per cent flower damage of 15.65 and 14.56 per cent compared to all other *Bt* cotton genotypes. Highest per cent flower damage of 22.57 was registered in (H × H) non *Bt* hybrid DCH-32, followed by (H × H) hybrid DHH-263 (19.83%) and the next higher damage recorded in *G. hirsutum* genotype Sahana (17.65%).

Green boll damage

There was a significant difference among the genotypes (Table 3). The highest per cent green boll damage was noticed at 135 DAS observation in all genotypes and started declining thereafter. However, lowest per cent of green boll damage was found in Everest (13.93%) and was on par with Jadoo (14.94%). While, BG-I hybrids MRC-6918 (H × B) and VCH-5 (H × H)

Table 3. Green boll damage due to pink bollworm in different *Bt* and non *Bt* cotton genotypes (Pooled)

Genotypes	Transgenic event	Per cent green boll damage						
		75 DAS	90 DAS	105 DAS	120 DAS	135 DAS	150 DAS	Mean
Bindas (H×H)	BG- II	1.56 (7.17)^{op}	5.48 (13.53)^{op}	11.65 (19.96)^{mn}	19.68 (26.33)^{mn}	24.83 (29.89)^{qr}	28.97 (32.56)^{no}	15.86 (23.47)^{op}
President gold (H×H)	BG- II	1.94 (8.01)^{mn}	5.84 (13.98)^{lm}	9.74 (18.19)^{pq}	22.09 (28.03)^{gh}	32.83 (34.96)^{ij}	29.37 (32.81)^{mn}	16.72 (24.14)^{no}
Jadoo (H×H)	BG-II	1.36 (6.70)^{pq}	5.18 (13.16)^{pq}	11.14 (19.49)^{op}	18.07 (25.16)^{op}	27.83 (31.84)^{op}	25.75 (30.49)^{pq}	14.94 (22.73)^{pq}
Everest (H×H)	BG- II	1.13 (6.10)^{qr}	5.02 (12.94)^{qr}	9.68 (18.13)^{qr}	15.88 (23.48)^{qr}	27.06 (31.35)^{pq}	24.37 (29.58)^{qr}	13.93 (21.91)^{qr}
First class (H×H)	BG- II	1.81 (7.73)^{no}	5.60 (13.68)^{no}	13.53 (21.58)^{jk}	20.08 (26.62)^{kl}	30.20 (33.33)^{no}	28.57 (32.31)^{op}	16.74 (24.15)^{mn}
ATM (H×H)	BG-II	2.49 (9.07)^{ij}	5.77 (13.89)^{mn}	12.97 (21.11)^{lm}	20.03 (26.58)^{lm}	31.61 (34.21)^{mn}	29.47 (32.88)^{lm}	17.09 (24.42)^{lm}
MRC-7351 (H×H)	BG-II	2.44 (8.98)^{jk}	5.88 (14.03)^{kl}	13.89 (21.88)^{ij}	20.47 (26.9)^{jk}	32.09 (34.51)^{kl}	30.19 (33.33)^{jk}	17.78 (24.94)^{jk}
MRC-7353 (H×H)	BG-II	2.43 (8.97)^{kl}	6.98 (15.31)^{jk}	14.3 (22.22)^{hi}	21.12 (27.36)^{ij}	32.44 (34.72)^{jk}	29.90 (33.15)^{kl}	17.54 (24.76)^{kl}
MRC-7918 (H×B)	BG-II	2.87 (9.75)^{fg}	7.89 (16.31)^{gh}	15.86 (23.47)^{f}	23.59 (29.06)^{ef}	34.37 (35.89)^{gh}	31.11 (33.9)^{hi}	19.15 (25.95)^{fg}
Puli (H×B)	BG-II	2.30 (8.71)^{lm}	7.09 (15.44)^{ij}	14.45 (22.34)^{gh}	21.46 (27.60)^{hi}	32.11 (34.51)^{lm}	30.84 (33.73)^{ij}	17.95 (25.06)^{ij}
Sowmya (H×B)	BG-II	2.71 (9.47)^{gh}	7.75 (16.16)^{hi}	15.39 (23.1)^{fg}	22.60 (28.39)^{fg}	33.31 (35.25)^{hi}	31.17 (33.94)^{gh}	18.49 (25.47)^{gh}
VCH-5 (H×H)	BG-I	4.59 (12.37)^{de}	9.90 (18.33)^{de}	20.30 (26.78)^{de}	26.52 (30.99)^{de}	39.29 (38.81)^{de}	32.80 (34.94)^{fg}	22.30 (28.18)^{de}
MRC-6918 (H×B)	BG-I	4.73 (12.55)^{cd}	10.56 (18.96)^{d}	20.72 (27.07)^{d}	26.92 (31.25)^{cd}	40.89 (39.75)^{c}	35.38 (36.5) ^{c}	23.13 (28.75)^{cd}
Arjun-21	GMF	2.96 (9.91)^{f}	8.58 (17.03)^{ef}	13.17 (21.28)^{kl}	19.55 (26.24)^{no}	37.25 (37.61)^{ef}	34.53 (35.99)^{cd}	19.29 (26.05)^{ef}
Profit+	GMF	2.69 (9.44)^{hi}	7.90 (16.32)^{fg}	11.17 (19.52)^{no}	17.77 (24.93)^{pq}	35.52 (36.58)^{fg}	33.46 (35.34)^{ef}	18.13 (25.2)^{hi}
DCH-32 (H×B)	Non *Bt*	9.34 (17.79)^{a}	18.73 (25.64)^{a}	29.79 (33.08)^{a}	51.31 (45.75)^{a}	69.82 (56.67)^{a}	72.22 (58.19)^{a}	41.26 (39.97)^{a}
DHH-263 (H×H)	Non *Bt*	4.73 (12.56)^{bc}	17.29 (24.57)^{ab}	28.43 (32.22)^{ab}	49.27 (44.58)^{ab}	66.85 (54.84)^{ab}	69.35 (56.38)^{ab}	39.29 (38.82)^{ab}
Sahana	Non *Bt*	5.70 (13.81)^{b}	15.12 (22.88)^{bc}	28.27 (32.12)^{bc}	36.11 (36.94)^{c}	40.20 (39.35)^{cd}	33.48 (35.35)^{de}	27.11 (31.38)^{c}
S.Em(±)	0.57	0.78	1.12	1.42	1.52	1.40	1.15	
C.D (p=0.05)	1.66	2.26	3.18	4.10	4.30	4.03	3.38	
C.V (%)	10.67	8.33	9.10	10.71	9.10	13.06	11.87	

* Figures in the parentheses are arcsine transformed values, Mean followed by the same alphabet in a column do not differ significantly (P=0.05) by DMRT, DAS: Days After Sowing

Table 4. Locule damage due to pink bollworm in different *Bt* and non *Bt* cotton genotypes (Pooled)

Genotypes	Transgenic event	Per cent locule damage			
		105 DAS	120 DAS	135 DAS	Mean
Bindas (H×H)	BG-II	9.97 (18.41)^{op}	12.22 (20.46)^{pq}	15.93 (23.52)^{pq}	13.89 (21.88)^{op}
President gold (H×H)	BG-II	10.88 (19.25)^{no}	14.33 (22.24)^{no}	17.20 (24.5)^{no}	14.28 (22.2)^{mn}
Jadoo (H×H)	BG-II	9.71 (18.16)^{pq}	12.82 (20.98)^{op}	16.84 (24.23)^{op}	11.06 (19.42)^{pq}
Everest (H×H)	BG-II	9.62 (18.06)^{qr}	11.50 (19.82)^{qr}	15.63 (23.29)^{qr}	10.88 (19.26)^{qr}
First class (H×H)	BG-II	10.95 (19.32)^{mn}	14.39 (22.29)^{mn}	17.31 (24.59)^{mn}	14.13 (22.08)^{no}
ATM (H×H)	BG-II	11.57 (19.88)^{kl}	15.35 (23.06)^{lm}	18.52 (25.49)^{kl}	15.14 (22.90)^{kl}
MRC-7351 (H×H)	BG-II	11.47 (19.79)^{lm}	15.65 (23.30)^{kl}	17.83 (24.97)^{lm}	14.98 (22.77)^{lm}
MRC-7353 (H×H)	BG-II	12.36 (20.58)^{jk}	18.31 (25.33)^{gh}	20.11 (26.64)^{hi}	16.92 (24.29)^{ij}
MRC-7918 (H×B)	BG-II	15.43 (23.13)^{ef}	18.45 (25.44)^{ef}	22.49 (28.31)^{ef}	21.39 (27.55)^{de}
Puli (H×B)	BG-II	13.85 (21.85)^{hi}	16.66 (24.09)^{ij}	20.13 (26.65)^{gh}	18.12 (25.19)^{gh}
Sowmya (H×B)	BG-II	14.49 (22.37)^{gh}	17.98 (25.09)^{hi}	21.05 (27.31)^{fg}	20.24 (26.74)^{fg}
VCH-5 (H×H)	BG-I	16.07 (23.63)^{de}	20.72 (27.08)^{de}	26.59 (31.04)^{de}	21.12 (27.36)^{ef}
MRC-6918 (H×B)	BG-I	19.83 (26.44)^{d}	25.55 (30.36)^{d}	32.09 (34.50)^{cd}	25.82 (30.54)^{d}
Arjun-21	GMF	14.71 (22.55)^{fg}	18.32 (25.34)^{fg}	19.81 (26.43)^{ij}	17.61 (24.81)^{hi}
Profit+	GMF	13.50 (21.55)^{ij}	16.60 (24.04)^{jk}	18.73 (25.64)^{jk}	16.27 (23.79)^{jk}
DCH-32 (H×B)	Non *Bt*	32.80 (34.94)^{a}	38.05 (38.08)^{a}	40.59 (39.57)^{a}	37.14 (37.55)^{a}
DHH-263 (H×H)	Non *Bt*	31.69 (34.26)^{ab}	35.05 (36.3)^{ab}	38.57 (38.39)^{ab}	35.10 (36.33)^{ab}
Sahana	Non *Bt*	30.74 (33.67)^{bc}	33.93 (35.63)^{bc}	34.84 (36.18)^{bc}	33.17 (35.16)^{bc}
S.Em(±)		1.08	1.33	1.30	1.12
C. D (p=0.05)		3.12	3.84	3.73	3.40
C .V (%)		8.58	9.45	8.42	8.49

*Mean followed by the same alphabet in a column do not differ significantly (P=0.05) by DMRT

recorded highest per cent boll damage of 23.13 and 22.30 per cent among all *Bt* genotypes. Highest per cent boll damage of 41.26 was recorded in (H × H) non *Bt* hybrid DCH-32, followed by (H × H) hybrid DHH-263 (39.29%) and the next higher damage recorded in Sahana (27.11%).

Locule damage

The highest locule damage was noticed at 135 DAS in all genotypes. Locule damage was least in Everest (BG-II) and Jadoo (BG-II) excelled over other genotypes by registering lowest locule damage of 10.88 and 11.06 per cent, respectively and both were being at par with eachother. However, BG-I hybrids MRC-6918 (H × B) and VCH-5 (H × H) recorded highest damage of 25.82 and 21.12 per cent among all *Bt* genotypes. Further, highest locule damage 37.14 per cent was recorded in H × H non *Bt* hybrid DCH-32, followed by DHH-263 (35.10%) and *G. hirsutum* genotype Sahana (33.17%).

Amongst different BG-II genotypes Everest was having least flower green boll damage and locule damage (Table 2, 3 and 4). The relatively lower flower, green boll damage and significantly lower larval recovery in Everest (BG-II) justify the hypothesis of cry toxin delivery in a homozygous pattern. In fact, it is only in India where hybrid formats of *Bt* cottons are grown. Thus it calls for development of homozygous hybrids for cry toxins. Further, the level of green boll damage was almost on par to Jadoo, Bindas and other BG-II hybrids and was followed by Profit + and Arjun-21 hybrids which had fusion gene. Thus, the fusion gene has certain promising potential but could not be an exclusive reliable tool for containing pink bollworm. The reports of Onkaramurthy *et al.* (2016) have also shown the promising performance of GMF event against pink bollworm and other bollworms. However, field survival of PBW in different events of cotton including GMF has been noticed in Andhra Pradesh (Naik *et al.*, 2016).On the contrary MRC-6918 had higher damage than MRC-7918 followed by Puli and Sowmya which almost adosed pattern of PBW incidence. Thus presence of Cry2Ab along with Cry1Ac has shown an advantage but not a mutually excluding way with respect to BG-I and GMF events. Lolita *et al.* (2018) have shown the resistance in laboratory and field selected populations to Cry2Ab with its molecular basis. In the similar line the results

Table 5. Kapas yield of different genotypes (Pooled)

Genotypes	Transgenic event	Total yield (q/ha)
Bindas (H×H)	BG-II	13.96^{bc}
President gold (H×H)	BG-II	13.02^{de}
Jadoo (H×H)	BG-II	14.32^{ab}
Everest (H×H)	BG-II	15.20^{a}
First class (H×H)	BG-II	13.11^{cd}
ATM (H×H)	BG-II	12.10^{ef}
MRC-7351 (H×H)	BG-II	11.95^{gh}
MRC-7353 (H×H)	BG-II	11.68^{hi}
MRC-7918 (H×B)	BG-II	10.73^{jk}
Puli (H×B)	BG-II	12.02^{fg}
Sowmya (H×B)	BG-II	11.01^{ij}
VCH-5 (H×H)	BG-I	9.84^{kl}
MRC-6918 (H×B)	BG-I	9.62^{lm}
Arjun-21	GMF	9.04^{mn}
Profit+	GMF	8.79^{no}
DCH-32 (H×B)	Non *Bt*	5.97^{qr}
DHH-263 (H×H)	Non *Bt*	6.87^{pq}
Sahana	Non *Bt*	7.19^{p}
S.Em(±)		0.38
C.D (p=0.05)		1.15
C.V (%)		7.26

*Mean followed by the same alphabet in a column do not differ significantly (P=0.05) by DMRT

were striking when the comparison was made between DCH-32, MRC-7918, Puli, Sowmya, MRC-6918 which are H × B cultivars. These genotypes have been hypothetically isogonics for the presence of Cry toxin. Thus, DCH-32 with no Cry toxin had higher damage, larval recovery followed by significantly lower in MRC-6918 as an impact of Cry1Ac and still lesser in Puli, MRC-7918 and Sowmya which were expressing dual toxins. However, the larval recovery as well as boll damage was high in both BG-I and non *Bt* formats as observed in earlier cases also (Badiger *et al.,* 2011, Naik *et al.,* 2016).

Seed cotton yield

Cotton yield of different hybrids indicated the significant differences among them (Table 5). Everest BG-IIexcelled over other genotypes by registering highest kapas yield of 15.20 q/ha and was followed by Jadoo with 14.32 q/ha but both were at par. While, BG-I hybrids MRC-6918 (H × B) and VCH-5 (H × H) recorded least yield of 9.62 and 9.84 q/ha seed cotton yield among all *Bt* genotypes. However, least yield of 5.97 q/ha was recorded in DCH-32 followed by DHH-263 (6.87 q/ha) and Sahana (7.19 q/ha) with no significant advantage than conventional hybrids.The limited variation of yield could be there among the genotypes due to the bearing pattern also. However, Everest BG-II had relatively lower bad kapas. On the contrary the non genotypes and DCH-32 had highest bad kapas proportion. Thus either in *Bt* or in conventional genotypes the yield loss perambulate around 50 per cent warranting the protection from insecticides, bio-agents, pheromone tools or by IPM approaches. The PBW impact on yield was evident in conventional cotton as well as selected *Bt* events (Sangareddy and Patil, 1997 Santosh *et al.* 2009).

Conclusion

Minimum pink bollworm infestation was recorded in *Bt* BG-II genotypes, compared to BG-I, GMF and non *Bt* genotypes. Among the genotypes, Everest BG-II hybrid yielded higher kapas followed by Jadoo In non-*Bt* genotypes yields were significantly lower. Despite resistance Bt cotton hybrids perfromed better over convential genotypes. Thuse adaptation of suitable PBW management strategoes are importent.

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