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V Chinna Babu Naik
Central Institute for Cotton Research (CICR), Nagpur, Maharashtra, India

Prasad NVVSD
Acharya NG Ranga Agricultural University, Rajendranagar, Hyderabad, Telangana, India

Vani Sree K
Acharya NG Ranga Agricultural University, Rajendranagar, Hyderabad, Telangana, India

Upendhar S
Acharya NG Ranga Agricultural University, Rajendranagar, Hyderabad, Telangana, India

Subbireddy KB
Central Institute for Cotton Research (CICR), Nagpur, Maharashtra, India

Correspondence
V Chinna Babu Naik
Central Institute for Cotton Research (CICR), Nagpur, Maharashtra, India

Frequency of sucking pest complex on different transgenic events of Cotton hybrids

V Chinna Babu Naik, Prasad NVVSD, Vani Sree K, Upendhar S and Subbireddy KB

Abstract
The present investigations on relative incidence of sucking pest complex on different *Bt* and non *Bt* hybrids was evaluated by recording the pest incidence *viz*., aphids, leafhoppers, thrips and whiteflies during *kharif*, 2007-08 and 2008-09 at Regional Agricultural Research Station, Lam, Guntur on four *Bt* cotton hybrids *viz*., RCH *2 Bt*, JK Durga *Bt*, Nath baba *Bt* and RCH 2 BGII *Bt* representing Mon 531event, JK Cry 1Ac event, GFM event and Mon 15985 event, respectively and RCH 2 non *Bt*, JK Durga non *Bt* and Nath baba non *Bt*. The lowest initial population of 1.20 aphids/3 leaves/plant was recorded on JK Durga non *Bt*. The thrips population reached its peak at 55 DAS with maximum of 18.46 thrips/3 leaves/plant on RCH 2 BG II and The leafhopper population reached its peak levels at 85 DAS 16.00 leafhoppers/3 leaves/plant and whitefly reached its maximum number at 100 DAS with 5.53 whiteflies/3 leaves/plant on RCH 2 BG II hybrids during 2007-08. Whereas, during 2008-09 the peak population of aphids was observed 115 DAS with minimum population was noticed on JK Durga non *Bt* (12.50 aphids/3 leaves/plant). The mean population of thrips was significantly lowest on Nath baba non *Bt* (6.82). Peak population of leaf hopper was recorded at 85 DAS with 11.33 to 15.07 leafhoppers/3 leaves/plant on different hybrids. Initially the whitefly population was noticed in negligible amounts up to 70 DAS and peak population was observed at 100 DAS with highest 6.36 whiteflies/3 leaves/plant RCH 2 BGII. The incidence of sucking pests in general was slightly high in *Bt* hybrid events compared to their corresponding non *Bt* versions.

Keywords: Cotton hybrids, *Bt*, *non Bt*, Sucking pests

1. Introduction
Cotton is the most important commercial crop in India. It occupies about 5 per cent of the arable land and supports 60 million people with direct bearing on the country's economy [4]. Cotton is grown in India in an area of 93.73 lakh hectares, with a total production of 290 lakh bales [3]. Though India has the largest area under cotton in the world, productivity is low due to biotic and abiotic stresses. Among them insect pests cause 50 per cent loss in seed cotton yield [18]. The problem of insect pests and their control is so intricate that as much as 56 per cent (50,000 tons of technical grade material) of total insecticides consumed in India is targeted to cotton crop, which occupies only 5.0 per cent of the total cultivated area [13]. Cotton is always an attractive host for several insect pests providing substratum for about 1326 species of insects from sowing to harvest. Of these, 156 species of insect pests have been reported from cotton ecosystem in India and a few of them have attained the pest status [2]. Among them, *Helicoverpa armigera* (Hubner); *Earias vitella* (Fabricius); *Pectinophora gossypiella* (Saunders); *Spodoptera litura* (Fabricius); *Bemisia tabaci* (Gennadius); *Amrasca biguttula biguttula* (Ishida) and *Aphis gossypii* (Glover) are of great concern accounting for an annual loss of 50-60 per cent of the total production [9]. Among the major insect pests, bollworms which cause damage mainly to the economic parts of the crop are the dreaded pests influencing the economic well-being of the cotton growers. The causes for repeated pest outbreaks and control failures may be due to pest resistance to most common and repeatedly used classes of insecticides and dwindling of natural enemies due to broad spectrum insecticides[12], warranting to search for alternate measures that are cost effective, selective and eco-friendly for the management of these noxious pests. Unhindered use of agrochemicals not only causes harm to the environment but also contribute to the development of resistance and resurgence in insect pests. At this juncture, advances made in the genetic engineering lead to the development of transgenic *Bt* cotton, which promise sustainable cotton production [7].

In India three hundred *Bt* hybrids with four *Bt* events were approved for commercial cultivation during 2008-2009 [6]. The performance of released *Bt* hybrid containing different *Bt* events were not uniform on all the lepidopteran pests and have no impact on sucking pest complex. To know the performance of *Bt* events towards infestation of sucking pest complex present investigations were carried.

2. Materials and Methods

The present study was carried at Regional Agricultural Research Station, Lam, Guntur on four *Bt* cotton hybrids *viz*., RCH *2 Bt*, JK Durga Bt, Nath baba *Bt* and RCH 2 BGII *Bt* representing Mon 531event, JK Cry 1Ac event, GFM event and Mon 15985 event, respectively and RCH 2 non *Bt*, JK Durga non *Bt* and Nath baba non *Bt* were selected for the study. Relative incidence of sucking pest complex on different *Bt* hybrids was evaluated by recording the pest incidence *viz*., aphids, leafhoppers, thrips, whiteflies, at 15 days intervals in all the test hybrids for two consecutive seasons, during *kharif*, 2007-08 and 2008-09. The experiment was laid out in a Randomized Block Design with seven treatments (T_1-RCH 2 *Bt*, T_2-RCH 2 non *Bt*, T_3-JK Durga *Bt*, T_4-JK Durga non *Bt*, T_5-Nath baba *Bt*, T_6-Nath baba non *Bt*, T_7- RCH 2 BGII) replicated thrice with plot size of 7.2 m X 6 m during both the seasons, with a spacing 120cm X 60cm. The field was kept completely under unsprayed conditions during the experimental period. Incidence of sucking pests were recorded from all the treatments *i.e*., RCH 2 *Bt*, RCH 2 BGII, JK Durga *Bt*, Nath baba *Bt* and their corresponding non *Bt* hybrids. Incidence of sucking pests *viz*., aphids, leafhoppers, whiteflies and thrips, were recorded from 5 randomly selected plants from each plot at 15 days interval throughout the cropping season. The population of both nymphs and adults for leafhoppers, aphids and thrips, while adult count for whiteflies were recorded from three leaves, one each from top, middle and bottom canopies of the plant.

Statistical analysis

The data obtained for sucking pests were analyzed by adopting square root transformation before statistical analysis following [10] data analysis was performed by ANOVA and means were separated using Lsd test at 5% level of significance.

3. Results

Kharif, 2007-08

Aphid, *A. gossypii*

Aphid population was recorded at 15 days interval on all hybrids starting from 10 days after sowing during *kharif* 2007-08 and presented in Table 1. The data indicated that the aphid population was increased gradually during vegetative stage of the crop upto 85 DAS. The lowest initial population of 1.20 aphids/3 leaves/plant was recorded on JK Durga non *Bt* compared to 2.4 aphids/3 leaves/plant on JK Durga *Bt* and RCH 2 BG II at 10 DAS. Sudden decline in the population was observed at 40 DAS in all the hybrids. The population reached its peak at 85 DAS with maximum population of 16.57, 16.27, 16.10 on JK Durga *Bt*, RCH 2 BG II, Nath baba *Bt* respectively, which are on par with each other and the population declined gradually from 100 DAS to 175 DAS. There was a significant difference in aphid population on all the hybrids. The mean aphid population during *kharif* 2007-08 indicated that there was no significance difference in the population level on hybrids. In general the aphid population was comparatively low in non *Bt* hybrids than *Bt* hybrids (Table 1).

Thrips, *T. tabaci*

The incidence of thrips started on cotton hybrids at 10 DAS and the initial population was low with maximum number of 3.76, 3.70 and 3.53 and 3.53 thrips on JK Durga *Bt*, RCH 2 BG II, RCH 2 *Bt* and Nath baba *Bt*, respectively on *Bt* cotton hybrids compared to non *Bt* cotton hybrids (Table 2). The population reached its peak at 55 DAS with maximum of 18.46 thrips/3 leaves/plant on RCH 2 BG II which is on par with RCH 2 non *Bt* (18.43), JK Durga *Bt* (18.36) and RCH2 *Bt* (18.23) cotton hybrids. After 55 DAS the thrips population gradually declined and reached its low level of 0.33 thrips/3 leaves/plant on RCH 2 *Bt* at 130 DAS. RCH 2 *Bt* hybrid was statistically on par with Nath baba non *Bt* (0.40 thrips/3 leaves/plant) and JK Durga non *Bt* (0.53 thrips/3 leaves/plant) (Table 2). The mean thrips population on the cotton hybrids showed a significant difference with maximum population of 6.93 thrips/3 leaves/plant on RCH2 *Bt* followed by JK Durga *Bt* (6.76), RCH 2 BGII (6.70), Nath baba *Bt* (6.66) and RCH 2 non *Bt* (6.25) cotton hybrids. The Nath baba non *Bt* (5.53), JK Durga non *Bt* (5.81) and RCH 2 non *Bt* (6.25) hybrids are statistically at par.

Leafhopper, *A. biguttula biguttula*

The leafhopper population build up at early vegetative stage *i.e.* upto 55 DAS was low (Table 3) and there was a sudden increase in population after 55 DAS. Thereafter reached its peak levels from 0.90 leafhoppers/3 leaves/plant at 10 DAS to 16.00 leafhoppers/3 leaves/plant at 85 DAS on RCH 2 BG II hybrid compared to low levels of leafhopper population recorded on JK Durga *Bt* (13.93 /3leaves/plant) hybrids at 85 DAS, which is statistically on par with Nath baba *Bt* (14.33) hybrid (Table 3). However, population declined gradually after 85 DAS till 175 DAS. The mean leafhopper population was maximum on RCH 2 BG II (4.73 leaf hoppesr/3 leaves/plant) followed by RCH 2 *Bt* (4.50) and RCH 2 Non *Bt* (4.44) hybrids and these are on par and significantly different from other hybrids.

Whiteflies, *B. tabaci*

The incidence of whitefly started at 10 DAS and gradually increased to its maximum at 100 DAS (Table 4). In all the *Bt* cotton hybrids, the whiteflies population was higher compared to non *Bt* hybrids at 100 DAS. The incidence of whiteflies at 100 DAS on non *Bt* cotton hybrids was low on Nath baba non *Bt* (4.26), JK Durga non *Bt* (4.53) and RCH 2 non *Bt* (4.53 whiteflies/3 leaves/plant) and are statistically on par with each other but significantly different from the *Bt* cotton hybrids. The whiteflies population on Bt hybrids gradually declined from 100 DAS to 175 DAS. There was no significant difference in mean population levels of whiteflies on different cotton hybrids tested (Table 4).

Kharif, 2008-09

Aphid, *A. gossypii*

The data pertaining to aphid population recorded during *kharif*, 2008-09 is presented in Table 5. The aphid population at 10 DAS was low on non *Bt* hybrids (1.93, 1.96 & 2.03 aphids/3 leaves/plant) on RCH 2 non *Bt*, JK Durga Non *Bt* and Nath Baba non *Bt* respectively, compared to *Bt* hybrids (2.26, 2.33, 2.46 and 2.53 aphids/3 leaves/plant) on Nath baba, JK RCH 2 & RCH BG II, respectively. The peak population of 15.00 aphids/3 leaves/plant was noticed on JK Durga *Bt* compared to 12.50 aphids/3 leaves/plant on JK Durga non *Bt* at 115 DAS. The aphid population declined thereafter from130 DAS to 190 DAS on all the cotton

hybrids. The mean population of aphids showed non-significant difference between the cotton hybrids. (Table 5).

Thrips, *T. tabaci*

Thrips population appeared at 10 DAS and reached its peak levels at 40 DAS. The maximum population of 19.63 thrips/3 leaves/plant was recorded on RCH 2 *Bt* at 40 DAS and it is statistically on par with other *Bt* cotton hybrids *viz.*, RCH 2 BG II (19.53), Nath baba *Bt* (19.33) and JK Durga *Bt* (18.80), Comparatively low level of thrips population was recorded on non *Bt* hybrids at 40 DAS (Table 6). After 40 DAS the thrips population gradually declined and reached its low levels in non *Bt* hybrids at 130 DAS. The mean thrips population was lower on RCH 2 non *Bt* (6.76 thrips/3 leaves/plant) followed by other non *Bt* hybrids *viz.*, Nath baba non *Bt* (6.82) and JK Durga non *Bt* (6.88). Whereas, *Bt* hybrids recorded high level population and are statistically different from the non *Bt* cotton hybrids (Table 6).

Leafhopper, *A. biguttula biguttula*

During *kharif* 2008-09, similar trend in leafhopper population build up from 10 DAS to 85 DAS was noticed. The leaf hopper population ranged from 0.27 leaf hoppers/3 leaves/plant at 10 DAS to 15.07 leaf hoppers/3 leaves/plant at 85 DAS (Table 7). There was a significant difference in population trends of leafhopper on different cotton hybrids at 85 DAS. JK Durga *Bt* (11.33), JK Durga non *Bt* (11.43) and Nath baba non *Bt* (11.37) recorded comparatively lower leafhopper population at 85 DAS and are statistically on par with each other and significantly different from other cotton hybrids. RCH BG II recorded maximum population of 15.07 leafhoppers/3 leaves/plant followed by RCH 2 *Bt* (14.87 leaf hoppers/3 leaves/plant) and are on par with each other at 85 DAS. The mean leafhopper population showed a significant difference in incidence levels on different cotton hybrids. Maximum leafhopper population was recorded on RCH 2 BG II with 5.15 leafhoppers/3 leaves/plant followed by RCH 2 *Bt* (5.15) and RCH 2 non *Bt* (5.03) hybrids (Table 7).

Whiteflies, *B. tabaci*

There was non-significant difference in population levels of whiteflies on cotton hybrids upto 40 DAS. The population gradually increased from 55 DAS to 100 DAS and reached its peak levels. A maximum of 6.36 whiteflies/3 leaves/plant was recorded on RCH 2 BG II and is statistically on par with other *Bt* cotton hybrids at 100 DAS. Thereafter, the population decreased gradually to non-significant levels at 175 DAS (Table 8). The mean population varied from 1.38 to 1.76 whiteflies/3 leaves/plant and was non-significant on all the cotton hybrids tested (Table 8).

4. Discussion

Results obtained from the performance of *Bt* cotton genotypes with one or two genes against sucking pest complex were discussed here under. The incidence of aphids was slightly high in *Bt* events compared to their corresponding non *Bt* versions. The mean aphid population during both the season indicated that there was no significance difference in the population level on all hybrids. In general the aphid population was comparatively low in non *Bt* hybrids than *Bt* hybrids. The present findings are in conformity with [1, 16, 19, 20] who reported higher incidence of aphids in *Bt* hybrids compared to non *Bt* hybrids. The incidence of thrips was slightly high in *Bt* hybrids events compared to their corresponding non *Bt* versions. The mean thrips population on the cotton hybrids showed a significant difference with maximum population on RCH 2 *Bt* followed by JK Durga *Bt*, RCH 2 BGII, Nath baba *Bt* and RCH 2 non *Bt* cotton hybrids. The present findings are in concurrence with the observation of [17, 15] who reported higher incidence of thrips on *Bt* cotton hybrids. However, [8] reported lower incidence of thrips in *Bt* cottons compared to check. The data clearly indicated that the *Bt* hybrids are more prone to sucking pests which is in agreement with [11]. The present studies revealed that the incidence of leafhopper was slightly high in *Bt* events compared to their corresponding non *Bt* versions. The mean leafhopper population was maximum on RCH 2 BG II followed by RCH 2 *Bt* and RCH 2 non *Bt* hybrids. These hybrids are statistically on par and significantly different from other hybrids. The most of the present observations revealed that RCH 2 *Bt* and RCH 2 BGII exhibited susceptibility to leafhopper by recording higher population. The present results were in agreement with [21, 17] who reported that MECH 12 hybrids are highly susceptible to leafhopper population. The incidence of whiteflies was slightly high in *Bt* events when compared to non *Bt* hybrids. Among the hybrids RCH 2 BG II recoded more whiteflies population. The results were in accordance with [8] indicating higher incidence of whiteflies on *Bt* lines compared to non *Bt* lines. Further [14] reported that the population of whitefly showed significant difference among hybrids.

Table 1: Incidence of *A. gossypii* during *kharif*, 2007-08.

Hybrids	Number of aphids/3 leaves/plant												
	Days after sowing												
	10	25	40	55	70	85	100	115	130	145	160	175	Mean
RCH 2 *Bt*	2.20 *(1.64)^{c}	5.47 (2.44)^{c}	0.97 (1.21)^{ab}	2.83 (1.82)^{b}	7.40 (2.81)^{b}	15.63 (4.01)^{bc}	7.23 (2.76)^{c}	5.10 (2.36)^{b}	4.60 (2.25)^{d}	2.20 (1.63)^{cd}	1.40 (1.37)^{ab}	0.67 (1.04)^{b}	4.64 (2.26)
RCH 2 non *Bt*	1.23 (1.31)^{a}	4.73 (2.28)^{a}	0.87 (1.16)^{a}	2.63 (1.77)^{a}	6.40 (2.62)^{a}	14.67 (3.89)^{ab}	6.43 (2.54)^{a}	4.27 (2.18)^{a}	4.00 (2.12)^{bc}	1.73 (1.49)^{abc}	1.17 (1.26)^{a}	0.27 (0.87)^{a}	4.03 (2.12)
JK Durga *Bt*	2.40 (1.70)^{c}	5.73 (2.49)^{d}	0.87 (1.16)^{a}	3.73 (2.05)^{d}	7.60 (2.84)^{b}	16.57 (4.13)^{c}	7.00 (2.73)^{ab}	5.27 (2.39)^{b}	3.93 (2.10)^{bc}	2.17 (1.57)^{abc}	1.33 (1.29)^{a}	0.53 (1.01)^{b}	4.77 (2.28)
JK Durga non *Bt*	1.20 (1.30)^{a}	5.10 (2.36)^{b}	0.80 (1.14)^{a}	2.60 (1.76)^{a}	6.67 (2.67)^{a}	14.20 (3.83)^{a}	6.03 (2.55)^{a}	3.73 (2.05)^{a}	3.60 (2.02)^{ab}	1.60 (1.44)^{ab}	1.27 (1.32)^{a}	0.33 (0.91)^{a}	3.93 (2.10)
Nath baba *Bt*	2.37 (1.69)^{c}	5.73 (2.49)^{d}	1.07 (1.25)^{bc}	3.33 (1.95)^{c}	7.73 (2.86)^{b}	16.10 (4.07)^{c}	7.10 (2.74)^{bc}	5.03 (2.35)^{b}	4.00 (2.12)^{c}	2.47 (1.71)^{d}	1.73 (1.47)^{b}	0.60 (1.04)^{b}	4.77 (2.28)
Nath baba non *Bt*	1.70 (1.48)^{b}	5.73 (2.49)^{d}	0.83 (1.15)^{a}	2.73 (1.79)^{ab}	6.40 (2.62)^{a}	14.47 (3.86)^{ab}	6.37 (2.62)^{ab}	4.03 (2.12)^{a}	3.27 (1.94)^{a}	1.53 (1.42)^{a}	1.07 (1.25)^{a}	0.27 (0.87)^{a}	4.03 (2.12)
RCH 2 BGII	2.40 (1.70)^{c}	5.87 (2.52)^{d}	1.20 (1.30)^{c}	3.80 (2.07)^{d}	7.40 (2.81)^{b}	16.27 (4.09)^{c}	7.20 (2.76)^{c}	5.67 (2.48)^{b}	4.33 (2.19)^{cd}	2.47 (1.66)^{d}	1.67 (1.47)^{b}	0.73 (1.10)^{b}	4.92 (2.31)
F-test	S	S	S	S	S	S	S	S	S	S	S	S	NS
SEm±	0.02	0.01	0.02	0.01	0.03	0.05	0.04	0.05	0.03	0.05	0.04	0.02	0.07
CD (P=0.05)	0.06	0.03	0.07	0.03	0.10	0.17	0.12	0.16	0.10	0.15	0.12	0.08	-

***Figures in parentheses are square root transformed values:** Numbers followed by same superscript are non-significant: S- Significant, NS- Non-significant

Table 2: Incidence of *T. tabaci* during *kharif*, 2007-08

Hybrids	Number of thrips /3 leaves/plant									
	Days after sowing									
	10	**25**	**40**	**55**	**70**	**85**	**100**	**115**	**130**	**Mean**
RCH 2 *Bt*	3.53 *(2.00)^{b}	2.33 (1.68)^{b}	14.76 (3.90)^{b}	18.23 (4.32)^{d}	4.30 (2.19)^{d}	9.16 (3.10)^{d}	7.63 (2.85)^{d}	2.13 (1.61)^{bc}	0.33 (0.91)^{a}	6.93 (2.70)^{c}
RCH 2 non *Bt*	2.86 (1.83)^{a}	1.66 (1.47)^{a}	14.53 (3.87)^{b}	18.43 (4.35)^{d}	2.23 (1.65)^{ab}	7.70 (2.86)^{b}	6.60 (2.66)^{bc}	1.56 (1.43)^{a}	0.70 (1.09)^{c}	6.25 (2.58)^{abc}
JK Durga *Bt*	3.76 (2.06)^{b}	2.13 (1.62)^{b}	14.73 (3.90)^{b}	18.36 (4.34)^{d}	3.23 (1.93)^{c}	8.13 (2.93)^{c}	7.26 (2.78)^{cd}	2.66 (1.77)^{d}	0.60 (1.04)^{bc}	6.76 (2.68)^{c}
JK Durga non *Bt*	2.76 (1.80)^{a}	1.70 (1.48)^{a}	14.46 (3.86)^{b}	15.43 (3.99)^{b}	2.20 (1.64)^{a}	7.36 (2.80)^{a}	6.20 (2.58)^{a}	1.73 (1.49)^{ab}	0.53 (1.01)^{abc}	5.81 (2.48)^{ab}
Nath baba *Bt*	3.53 (2.00)^{b}	2.20 (1.64)^{b}	14.50 (3.87)^{b}	17.46 (4.23)^{c}	3.16 (1.91)^{c}	9.13 (3.10)^{d}	7.20 (2.77)^{cd}	2.16 (1.63)^{bcd}	0.66 (1.07)^{c}	6.66 (2.66)^{c}
Nath baba non *Bt*	2.80 (1.81)^{a}	1.63 (1.46)^{a}	12.70 (3.63)^{a}	14.56 (3.88)^{a}	2.33 (1.68)^{ab}	7.56 (2.84)^{ab}	6.40 (2.62)^{ab}	1.46 (1.40)^{a}	0.40 (0.94)^{ab}	5.53 (2.43)^{a}
RCH 2 BGII	3.70 (2.04)^{b}	2.10 (1.61)^{b}	12.73 (3.63)^{a}	18.46 (4.35)^{d}	3.46 (1.99)^{d}	9.60 (3.17)^{e}	7.66 (2.85)^{d}	1.83 (1.52)^{d}	0.76 (1.12)^{c}	6.70 (2.66)^{c}
F-test	S	S	S	S	S	S	S	S	S	S
SEm±	0.03	0.03	0.01	0.01	0.01	0.01	0.04	0.05	0.03	0.06
CD (P=0.05)	0.11	0.10	0.04	0.03	0.04	0.04	0.12	0.15	0.11	0.18

*Figures in parentheses are square root transformed values: Numbers followed by same superscript are non-significant: S-Significant, NS-Non-significant

Table 3: Incidence of *A. biguttula biguttula* during *kharif*, 2007-08

Hybrids	Number of leaf hoppers /3 leaves/plant												
	Days after sowing												
	10	**25**	**40**	**55**	**70**	**85**	**100**	**115**	**130**	**145**	**160**	**175**	**Mean**
RCH 2 *Bt*	0.93 *(1.20)^{d}	2.40 (1.70)^{c}	3.80 (2.07)^{b}	4.60 (2.26)^{c}	13.80 (3.78)^{c}	15.73 (4.03)^{c}	5.93 (2.54)^{c}	2.33 (1.68)^{b}	1.87 (1.54)^{d}	1.33 (1.35)^{c}	0.87 (1.17)^{bcd}	0.40 (0.92)^{ab}	4.50 (2.23)^{c}
RCH 2 non *Bt*	0.83 (1.15)^{bcd}	2.17 (1.63)^{bc}	3.87 (2.09)^{b}	4.63 (2.27)^{c}	13.77 (3.77)^{c}	15.67 (4.02)^{c}	5.83 (2.52)^{c}	2.27 (1.66)^{b}	1.80 (1.52)^{d}	1.20 (1.30)^{c}	0.67 (1. 08)^{abc}	0.53 (1.02)^{cd}	4.44 (2.22)^{c}
JK Durga *Bt*	0.77 (1.13)^{abcd}	1.73 (1.49)^{ab}	3.00 (1.87)^{a}	3.50 (2.00)^{ab}	12.03 (3.54)^{a}	13.93 (3.80)^{a}	4.57 (2.25)^{ab}	1.87 (1.54)^{a}	1.07 (1.25)^{a}	0.87 (1.17)^{a}	0.47 (0.98)^{a}	0.20 (0.84)^{a}	3.67 (2.04)^{a}
JK Durga non *Bt*	0.63 (1.06)^{a}	1.83 (1.53)^{ab}	2.77 (1.80)^{a}	3.33 (1.96)^{a}	12.87 (3.66)^{b}	14.60 (3.89)^{b}	4.40 (2.21)^{a}	1.97 (1.57)^{a}	1.40 (1.38)^{b}	1.03 (1.23)^{bc}	0.60 (1.05)^{ab}	0.27 (0.87)^{ab}	3.81 (2.08)^{ab}
Nath baba *Bt*	0.73 (1.11)^{abc}	1.80 (1.52)^{ab}	2.93 (1.85)^{a}	3.83 (2.08)^{b}	12.17 (3.56)^{a}	14.33 (3.85)^{ab}	5.07 (2.36)^{b}	1.93 (1.56)^{a}	1.17 (1.29)^{a}	0.97 (1.21)^{ab}	0.47 (0.98)^{a}	0.27 (0.87)^{ab}	3.81 (2.08)^{ab}
Nath baba non *Bt*	0.67 (1.08)^{ab}	1.50 (1.41)^{a}	3.07 (1.89)^{a}	3.53 (2.01)^{ab}	12.03 (3.54)^{a}	14.60 (3.89)^{b}	4.43 (2.22)^{a}	1.97 (1.57)^{a}	1.62 (1.45)^{c}	1.00 (1.22)^{ab}	0.73 (1.11)^{bc}	0.40 (0.95)^{bc}	3.80 (2.07)^{ab}
RCH 2 BGII	0.90 (1.18)^{d}	2.43 (1.71)^{c}	4.00 (2.12)^{b}	4.80 (2.30)^{c}	14.00 (3.81)^{c}	16.00 (4.06)^{c}	6.40 (2.63)^{c}	3.00 (1.87)^{c}	2.00 (1.58)^{d}	1.67 (1.47)^{d}	1.00 (1.22)^{d}	0.60 (1.05)^{d}	4.73 (2.28)^{c}
F-test	S	S	S	S	S	S	S	S	S	S	S	S	S
SEm±	0.02	0.05	0.03	0.03	0.02	0.03	0.04	0.02	0.02	0.02	0.03	0.02	0.03
CD (P=0.05)	0.07	0.15	0.10	0.09	0.06	0.08	0.11	0.07	0.06	0.06	0.10	0.09	0.10

*Figures in parentheses are square root transformed values: Numbers followed by same superscript are non-significant: S-Significant, NS-Non-significant

Table 4: Incidence of *B. tabaci* during *kharif*, 2007-08

Hybrids	Number of whiteflies / 3 leaves / plant												
	Days after sowing												
	10	**25**	**40**	**55**	**70**	**85**	**100**	**115**	**130**	**145**	**160**	**175**	**Mean**
RCH 2 *Bt*	0.53 *(1.01)	1.10 (1.26)	1.46 (1.40)^{a}	2.40 (1.70)^{b}	3.13 (1.90)^{bc}	4.13 (2.15)^{bc}	5.46 (2.44)^{b}	4.46 (2.22)^{c}	3.06 (1.88)	2.46 (1.72)^{bc}	5.20 (2.38)^{d}	0.53 (1.01)^{bc}	2.83 (1.81)
RCH 2 non *Bt*	0.60 (1.04)	1.00 (1.22)	2.00 (1.58)^{d}	2.60 (1.76)^{bc}	2.80 (1.81)^{ab}	3.60 (2.02)^{a}	4.53 (2.24)^{a}	3.60 (2.02)^{b}	2.70 (1.78)	1.60 (1.44)^{a}	4.33 (2.19)^{ab}	0.20 (0.83)^{a}	2.46 (1.71)
JK Durga *Bt*	0.73 (1.11)	1.23 (1.31)	1.80 (1.51)^{bcd}	2.06 (1.60)^{a}	3.26 (1.94)^{c}	3.93 (2.10)^{ab}	5.26 (2.40)^{b}	4.33 (2.19)^{c}	3.13 (1.89)	2.33 (1.68)^{bc}	4.60 (2.25)^{bc}	0.60 (1.04)^{cd}	2.77 (1.80)
JK Durga non *Bt*	0.76 (1.12)	1.23 (1.31)	1.73 (1.49)^{bc}	2.46 (1.72)^{bc}	2.86 (1.83)^{ab}	3.60 (2.02)^{a}	4.53 (2.24)^{a}	3.20 (1.92)^{a}	2.73 (1.79)	1.66 (1.47)^{a}	4.66 (2.27)^{bc}	0.46 (0.98)^{bc}	2.46 (1.71)
Nath baba *Bt*	0.66 (1.07)	1.06 (1.25)	1.86 (1.53)^{bcd}	2.16 (1.63)^{a}	3.46 (1.99)^{cd}	4.53 (2.24)^{c}	5.40 (2.42)^{b}	4.13 (2.15)^{c}	3.26 (1.94)	2.53 (1.74)^{c}	4.73 (2.28)^{c}	0.73 (1.11)^{de}	2.88 (1.83)
Nath baba non *Bt*	0.46 (0.98)	1.16 (1.29)	1.93 (1.56)^{d}	2.53 (1.74)^{bc}	2.73 (1.79)^{a}	3.73 (2.05)^{ab}	4.26 (2.18)^{a}	3.40 (1.97)^{a}	2.70 (1.78)	2.13 (1.62)^{b}	4.06 (2.13)^{a}	0.40 (0.94)^{b}	2.46 (1.71)
RCH 2 BGII	0.66 (1.07)	1.03 (1.23)	1.66 (1.47)^{ab}	2.66 (1.77)^{c}	3.80 (2.07)^{d}	4.53 (2.24)^{c}	5.53 (2.45)^{b}	4.50 (2.23)^{c}	3.20 (1.92)	2.60 (1.76)^{c}	4.86 (2.31)^{cd}	0.80 (1.14)^{e}	2.99 (1.86)
F-test	NS.	NS.	S	S	S	S	S	S	NS	S	S	S	NS
SEm±	0.03	0.02	0.02	0.01	0.03	0.03	0.04	0.03	0.06	0.03	0.02	0.02	0.05
CD (P=0.05)	-	-	0.08	0.06	0.09	0.11	0.12	0.09	--	0.11	0.08	0.09	--

*Figures in parentheses are square root transformed values: Numbers followed by same superscript are non-significant: S-Significant, NS-Non-significant

Table 5: Incidence of *A. gossypii* during *kharif*, 2008-09

Hybrids	Number of aphids / 3 leaves / plant													
	Days after sowing													
	10	25	40	55	70	85	100	115	130	145	160	175	190	Mean
RCH 2 *Bt*	2.46 *(1.72)^{d}	5.73 (2.49)^{cd}	1.06 (1.25)^{c}	1.23 (1.31)^{f}	1.23 (1.31)^{c}	3.46 (1.99)^{c}	7.30 (2.79)^{c}	14.10 (3.82)^{c}	6.90 (2.72)^{d}	4.76 (2.29)^{e}	1.43 (1.38)^{b}	0.73 (1.11)^{d}	0.20 (0.83)^{cd}	3.89 (2.09)
RCH 2 non *Bt*	1.93 (1.56)^{a}	4.93 (2.33)^{a}	0.73 (1.11)^{b}	0.83 (1.15)^{c}	0.86 (1.16)^{b}	2.83 (1.82)^{b}	6.83 (2.70)^{b}	12.86 (3.65)^{b}	6.03 (2.55)^{b}	3.56 (2.01)^{b}	1.13 (1.27)^{a}	0.40 (0.94)^{b}	0.10 (0.77)^{a}	3.30 (1.94)
JK Durga *Bt*	2.33 (1.68)^{c}	5.60 (2.46)^{c}	1.13 (1.27)^{c}	0.86 (1.16)^{c}	1.30 (1.34)^{c}	3.66 (2.04)^{d}	7.30 (2.79)^{c}	15.00 (3.93)^{d}	6.73 (2.68)^{c}	4.63 (2.26)^{de}	1.53 (1.42)^{b}	0.80 (1.14)^{e}	0.26 (0.87)^{e}	3.91 (2.09)
JK Durga non *Bt*	1.96 (1.57)^{ab}	5.36 (2.42)^{b}	0.50 (0.98)^{a}	0.76 (1.12)^{b}	0.56 (1.01)^{a}	2.73 (1.79)^{a}	6.76 (2.69)^{b}	12.50 (3.60)^{a}	5.43 (2.43)^{a}	3.90 (2.09)^{c}	1.06 (1.24)^{a}	0.33 (0.91)^{a}	0.10 (0.77)^{a}	3.22 (1.92)
Nath baba *Bt*	2.26 (1.66)^{c}	5.66 (2.48)^{cd}	1.06 (1.25)^{c}	1.03 (1.23)^{e}	1.26 (1.32)^{c}	3.50 (2.00)^{c}	7.30 (2.79)^{c}	14.20 (3.83)^{c}	6.53 (2.65)^{c}	4.533 (2.24)^{d}	1.70 (1.48)^{c}	0.73 (1.11)^{d}	0.23 (0.85)^{de}	3.82 (2.07)
Nath baba non *Bt*	2.03 (1.59)^{b}	5.40 (2.42)^{b}	0.66 (1.08)^{b}	0.53 (1.01)^{a}	0.86 (1.16)^{b}	2.86 (1.83)^{b}	6.53 (2.65)^{a}	12.96 (3.67)^{b}	6.10 (2.56)^{b}	3.13 (1.90)^{a}	1.00 (1.22)^{a}	0.46 (0.98)^{c}	0.13 (0.79)^{ab}	3.28 (1.93)
RCH 2 BGII	2.53 (1.74)^{d}	6.26 (2.60)^{d}	1.10 (1.26)^{c}	0.93 (1.19)^{d}	1.20 (1.30)^{c}	3.76 (2.06)^{e}	7.46 (2.82)^{d}	14.33 (3.85)^{c}	7.16 (2.76)^{e}	4.93 (2.33)^{f}	1.80 (1.51)^{c}	0.86 (1.16)^{e}	0.16 (0.81)^{bc}	4.03 (2.12)
F-test	S	S	S	S	S	S	S	S	S	S	S	S	S	NS
SEm±	0.06	0.11	0.13	0.08	0.14	0.05	0.05	0.14	0.09	0.09	0.15	0.08	0.06	0.06
CD (P=0.05)	0.02	0.03	0.04	0.02	0.04	0.01	0.01	0.04	0.03	0.03	0.05	0.02	0.02	-

*Figures in parentheses are square root transformed values: Numbers followed by same superscript are non-significant: S-Significant, NS-Non-significant

Table 6: Incidence of *T. tabaci* during *kharif*, 2008-09

Number of thrips /3 leaves/ plant										
Days after sowing										
Hybrids	10	25	40	55	70	85	100	115	130	Mean
RCH 2 *Bt*	14.50 *(3.87)^{c}	18.20 (4.32)^{c}	19.63 (4.48)^{b}	10.43 (3.30)^{b}	3.46 (1.99)^{b}	2.20 (1.64)^{b}	1.16 (1.29)	0.83 (1.15)^{c}	0.20 (0.83)^{bc}	7.84 (2.87)^{b}
RCH 2 non *Bt*	13.50 (3.74)^{b}	16.26 (4.09)^{ab}	16.80 (4.15)^{a}	9.13 (3.10)^{a}	2.43 (1.71)^{a}	1.36 (1.36)^{a}	0.86 (1.16)	0.46 (0.98)^{a}	0.06 (0.75)^{a}	6.76 (2.67)^{a}
JK Durga *Bt*	13.90 (3.79)^{bc}	18.23 (4.32)^{c}	18.80 (4.39)^{b}	9.50 (3.16)^{a}	3.43 (1.98)^{b}	2.13 (1.62)^{b}	1.03 (1.23)	0.66 (1.07)^{b}	0.20 (0.83)^{bc}	7.54 (2.82)^{b}
JK Durga non *Bt*	13.40 (3.72)^{b}	16.56 (4.13)^{b}	16.53 (4.12)^{a}	10.43 (3.30)^{b}	2.40 (1.70)^{a}	1.36 (1.36)^{a}	0.80 (1.14)	0.40 (0.94)^{a}	0.10 (0.77)^{ab}	6.88 (2.70)^{a}
Nath baba *Bt*	14.40 (3.86)^{c}	18.10 (4.31)^{c}	19.33 (4.45)^{b}	10.40 (3.30)^{b}	3.46 (1.99)^{b}	2.26 (1.66)^{b}	0.96 (1.21)	0.80 (1.14)^{c}	0.16 (0.81)^{abc}	7.76 (2.86)^{b}
Nath baba non *Bt*	12.46 (3.60)^{a}	16.16 (4.08)^{a}	16.90 (4.17)^{a}	10.33 (3.29)^{b}	2.50 (1.73)^{a}	1.23 (1.31)^{a}	1.00 (1.22)	0.73 (1.11)^{bc}	0.13 (0.79)^{abc}	6.82 (2.68)^{a}
RCH 2 BGII	14.50 (3.87)^{c}	18.36 (4.34)^{c}	19.53 (4.47)^{b}	10.56 (3.32)^{b}	3.86 (2.09)^{b}	2.73 (1.79)^{c}	1.06 (1.25)	0.80 (1.14)c	0.23 (0.85)^{c}	7.95 (2.89)^{b}
F-test	S	S	S	S	S	S	NS	S	S	S
SEm±	0.02	0.01	0.03	0.02	0.04	0.03	0.03	0.02	0.02	0.03
CD (P=0.05)	0.08	0.04	0.10	0.08	0.12	0.09	-	0.06	0.06	0.10

*Figures in parentheses are square root transformed values: Numbers followed by same superscript are non-significant: S-Significant, NS-Non-significant

Table 7: Incidence of *A. biguttula biguttula* during *kharif*, 2008-09

Hybrids	Number of leafhoppers /3 leaves/plant												
	Days after sowing												
	10	25	40	55	70	85	100	115	130	145	160	175	Mean
RCH 2 *Bt*	0.87 *(0.17)	2.27 (1.66)^{b}	4.07 (2.14)	6.15 (2.61)^{c}	12.23 (3.58)^{c}	14.87 (3.92)^{cd}	9.80 (3.21)^{c}	6.30 (2.61)^{b}	2.93 (1.85)^{de}	1.00 (1.22)^{bc}	0.80 (1.14)	0.20 (0.84)	5.15 (2.37)^{c}
RCH 2 non *Bt*	0.80 (1.14)	2.20 (1.64)^{b}	4.03 (2.13)	6.00 (2.56)^{c}	12.20 (3.57)^{c}	14.70 (3.90)^{c}	9.60 (3.18)^{c}	6.07 (2.56)^{b}	2.87 (1.83)^{d}	1.07 (1.25)^{bc}	0.73 (1.11)	0.20 (0.84)	5.03 (2.34)^{c}
JK Durga *Bt*	0.40 (0.95)	1.93 (1.56)^{ab}	3.07 (1.89)	5.40 (2.43)^{b}	11.00 (3.39)^{ab}	11.33 (3.44)^{a}	8.40 (2.98)^{b}	5.20 (2.39)^{a}	1.57 (1.44)^{c}	0.87 (1.17)^{b}	0.53 (1.02)	0.17 (0.82)	4.15 (2.15)^{ab}
JK Durga non *Bt*	0.27 (0.88)	1.67 (1.47)^{a}	3.10 (1.90)	5.73 (2.50)^{b}	10.77 (3.36)^{a}	11.43 (3.45)^{a}	7.90 (2.90)^{ab}	5.17 (2.38)^{a}	1.17 (1.29)^{a}	0.73 (1.11)^{b}	0.17 (0.82)	0.13 (0.80)	4.02 (2.11)^{ab}
Nath baba *Bt*	0.50 (1.00)	1.83 (1.53)^{a}	3.23 (1.93)	5.13 (2.37)^{a}	11.13 (3.41)^{b}	11.93 (3.53)^{b}	7.97 (2.91)^{ab}	5.37 (2.42)^{a}	1.50 (1.41)^{bc}	0.77 (1.12)^{b}	0.33 (0.91)	0.10 (0.77)	4.14 (2.14)^{ab}
Nath baba non *Bt*	0.40 (0.94)	1.73 (1.49)^{a}	2.93 (1.85)	5.07 (2.36)^{a}	10.60 (3.33)^{a}	11.37 (3.44)^{a}	7.40 (2.81)^{a}	5.27 (2.40)^{a}	1.27 (1.33)^{ab}	0.27 (0.87)^{a}	0.47 (0.98)	0.13 (0.80)	3.90 (2.09)^{a}
RCH 2 BGII	0.80 (1.14)	3.00 (1.87)^{b}	4.20 (2.17)	6.30 (2.61)^{d}	13.00 (3.67)^{c}	15.07 (3.95)^{d}	10.07 (3.25)^{c}	7.07 (2.75)^{c}	3.20 (1.92)^{e}	1.33 (1.35)^{c}	0.87 (1.17)	0.27 (0.87)	5.15 (2.43)^{c}
F-test	NS	S	NS	S	S	S	S	S	S	S	NS.	NS	S
SEm±	0.03	0.02	0.02	0.02	0.05	0.01	0.03	0.02	0.02	0.05	0.04	0.02	0.06
CD (P=0.05)	-	0.07	-	0.05	0.15	0.03	0.10	0.05	0.08	0.14	-	-	0.19

*Figures in parentheses are square root transformed values: Numbers followed by same superscript are non-significant: S-Significant, NS-Non-significant

Table 8: Incidence of *B. tabaci* during *kharif*, 2008-09

Hybrids	Number of whiteflies /3 leaves/ plant												
	Days after sowing												
	10	25	40	55	70	85	100	115	130	145	160	175	Mean
RCH 2 *Bt*	0.10 *(0.77)	0.20 (0.83)	0.46 (0.98)	0.60 $(1.04)^{bcd}$	1.20 $(1.30)^{b}$	3.16 $(1.91)^{b}$	6.06 $(2.56)^{bcd}$	3.50 $(1.99)^{cd}$	2.16 $(1.63)^{c}$	1.13 $(1.27)^{bc}$	0.80 $(1.14)^{c}$	0.20 (0.83)	1.63 (1.45)
RCH 2 non *Bt*	0.16 (0.81)	0.26 (0.87)	0.33 (0.91)	0.46 $(0.97)^{b}$	0.86 $(1.16)^{a}$	2.83 $(1.82)^{a}$	5.73 $(2.49)^{abc}$	3.16 $(1.91)^{bc}$	1.83 $(1.52)^{b}$	0.80 $(1.14)^{a}$	0.26 $(0.87)^{a}$	0.06 (0.75)	1.39 (1.37)
JK Durga *Bt*	0.13 (0.79)	0.46 (0.98)	0.33 (0.91)	0.53 $(1.01)^{bc}$	1.33 $(1.35)^{b}$	3.30 $(1.94)^{bc}$	6.26 $(2.60)^{cd}$	3.53 $(2.00)^{cd}$	2.33 $(1.68)^{c}$	1.30 $(1.34)^{c}$	0.93 $(1.19)^{c}$	0.16 (0.81)	1.71 (1.48)
JK Durga non *Bt*	0.20 (0.83)	0.20 (0.83)	0.60 (1.04)	0.26 $(0.87)^{a}$	1.83 $(1.52)^{d}$	2.80 $(1.81)^{a}$	5.56 $(2.46)^{ab}$	2.83 $(1.82)^{ab}$	1.80 $(1.51)^{b}$	0.73 $(1.11)^{a}$	0.40 $(0.94)^{ab}$	0.13 (0.79)	1.44 (1.39)
Nath baba *Bt*	0.23 (0.85)	0.33 (0.91)	0.46 (0.98)	0.73 $(1.11)^{d}$	1.23 $(1.31)^{b}$	3.43 $(1.98)^{c}$	6.23 $(2.59)^{cd}$	3.66 $(2.04)^{d}$	2.36 $(1.69)^{c}$	1.20 $(1.30)^{c}$	0.73 $(1.11)^{c}$	0.10 (0.77)	1.72 (1.49)
Nath baba non *Bt*	0.13 (0.79)	0.40 (0.94)	0.400 (0.94)	0.60 $(1.04)^{bcd}$	1.60 $(1.44)^{c}$	2.90 $(1.84)^{a}$	5.23 $(2.39)^{a}$	2.56 $(1.75)^{a}$	1.46 $(1.40)^{a}$	0.73 $(1.11)^{a}$	0.53 $(1.01)^{b}$	0.13 (0.79)	1.38 (1.37)
RCH 2 BGII	0.26 (0.87)	0.26 (0.87)	0.53 (1.01)	0.66 $(1.07)^{cd}$	1.66 $(1.47)^{cd}$	3.36 $(1.96)^{c}$	6.36 $(2.62)^{d}$	3.80 $(2.07)^{d}$	2.20 $(1.64)^{c}$	1.00 $(1.22)^{b}$	0.86 $(1.16)^{c}$	0.20 (0.83)	1.76 (1.50)
F-test	NS	NS	NS	S	S	S	S	S	S	S	S	NS	NS
SEm+	0.02	0.03	0.04	0.02	0.02	0.01	0.04	0.03	0.02	0.02	0.02	0.02	0.04
CD(P=0.05)	-	-	-	0.08	0.06	0.04	0.12	0.11	0.09	0.07	0.08	-	-

*Figures in parentheses are square root transformed values: Numbers followed by same superscript are non-significant: S-Significant, NS-Non-significant

5. Conclusion

From the present investigations it is evident that sucking pest complex incidence is much higher in *Bt* events compared to non *Bt* probably due to there is no competition from other insect species and may be due to nutritional components in the cultivars has to be reinvestigated. The genetic background of the hybrids also may cause the more incidences on *Bt* cotton.

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