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Relative Performance of Bt-Cotton Hybrids against Sucking Pests and Leaf Reddening under Rainfed Farming

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Abstract

Bt-cotton currently occupies over 93% of the area under cotton cultivation. Genetic makeup of the plant is very much important to confer tolerance to biotic and abiotic stress under natural conditions. In India, introduction of Bt-cotton involving several hybrids, most of which were highly susceptible to sucking pests has resulted in increased crop damage. Fifty four Bt-cotton hybrids were evaluated for genetic tolerance to sucking pests and leaf reddening under rainfed farming. Data on population counts were recorded at weekly intervals, leaf reddening at 108 DAS and yield at the end of season. The study revealed Ankur 3070 BG II, Durga BG, Atal BG II, Krish BG II, Ryan BG, Madhura BG, MRC 7301 BG II, SP 504 BG II, Namskar BG II, Mahi BG II, VICH 312 BG II, Ankur 3028 BG, Anvitha BG, VICH 304 BG II, Ankur 3034 BG II, VICH 311 BG II, Ankur Jai BG II, Ankur 216 BG II, Ankur 3042 BG II, Vanaja BG, VICH 301 BG II, Classic BG II, Bunny BG II, Menaka BG II, VICH 314 BG II, Veda 2 BG II, VICH 303 BG II were tolerant to leafhoppers. No significant difference in whitefly population was recorded across the Bt-cotton hybrids. Ankur 2104 BG II, Atal BG II, Madhura BG, Mahadev BG II, Anvitha BG, Mahi BG II, VICH 313 BG II,VICH 301 BG II, Kohinoor BG, SP 504 BG II, VICH 311 BG II, Krish BG II, Aadhar BG, Vanaja BG, Dyna BG II, Ankur 3070 BG II, Namskar BG II, Ishwar BG, Ryan BG, Bunny BG II, Superman BG II, MRC 7301 BG II, Ankur 257 BG II, Durga BG, Shrimanth BG, Classic BG II, Ankur 3034 BG II, VICH 312 BG II, Express BG II, Manjeet BG II, MRC-7383 BG II, Ankur Jai BG II, Menaka BG II, ALTO BG II, RCH 530 BG II, Ankur 3042 BG II, VICH 303 BG II, JKCH 99 BG harbours lowest thrips population. Bt-cotton hybrids JKCH 99 BG, Ankur 3042 BG II, Menaka BG II, Mahadev BG II, Classic BG II, VICH 301 BG II, Ankur Jai BG II, Madhura BG, Veda 2 BG II and Ryan BG indicated tolerance to mirids. Ankur 3042 BG II, Ankur Jai BG II, Classic BG II, Madhura BG, Menaka BG II, Ryan BG and VICH 301 BG II were found tolerant to all the three sucking pests under study. Atal BG II, Ankur Jai BG II, MRC 7301 BG II, VICH 303 BG II, Ankur 216 BG II, Ankur 3042 BG II, VICH 304 BG II, Paras Krishna BG II, Uttam BG II, Express BG II were free from leaf reddening. Highest yield (Kg/ha) gainers were MRC 7301 BG II (1955.48), Krish BG II (1779), RCH 530 BG II (1765), Atal BG II (1741), Bunny BG (1666), Uttam BG II (1638), Classic BG II (1594), Shrimanth BG (1590), ALTO BG II (1583), Krishna BG II (1562) and Ryan BG (1539). The results from this study provide an option for cotton stakeholders to choose tolerant hybrids so that indiscriminate insecticide sprays can be reduced.

Keywords: Bt-cotton hybrids; Leafhoppers; Thrips; Whitefly; Mirids; Leaf reddening; Rainfed farming

Introduction

Genetically modified cotton, popularly known as 'Bt-cotton' with bacterial (Bacillus thuringiensis) toxin gene cry1Ac was first developed and commercialized by Monsanto in India. Since the introduction (2002) of Bt-cotton, cultivation has spread throughout all major cotton growing areas of the country with an estimated 93% of the cotton area under Bt-cotton by 2010-11 [1]. Several genes such as cry1Ac, cry2Ab, cry1C, cry1F, vip3A and protease inhibitors were deployed for the development of Bt-cotton meant targeted against cotton bollworms. Bt genes are specifically toxic to bollworms and exhibits high level of safety to non-target organisms such as beneficial insects, birds, fish, animals and human beings [2]. Updated list of Bt-cotton hybrids indicated that about 1028 Bt-cotton hybrids from six events commercialized by more than 35 seed companies have been released for cultivation through Genetic Engineering Appraisal Committee (GEAC) in three cotton growing zones of India.

Introduction of several Bt-cotton hybrids, most of which were susceptible to insect pests has resulted in increased damage by sucking pests such as leafhoppers (Amrasca biguttula biguttula Ishida), whiteflies (Bemesia tabaci Gennadius), thrips (Thrips tabaci Lind) and mirid bug (Campylomma livida Reuter). During 2007-08, mealybug (Phenacoccus solenopsis Tinsley) caused significant damage to cotton across India [3]. As a consequence of this, insecticide usage which had declined from Rs. 10520 million in 2001 to Rs. 5790 million in 2006, increased gradually to Rs. 8804 M by 2010 [4]. Bt-cotton cultivars thus effectively protected the crop from bollworms, especially Helicoverpa armigera (Hubner) that helped in reducing insecticide use and cost besides preventing yield losses. The changes in pest management systems with reduction in pesticides however subsequently led to changed pest scenario with sucking pests having an opportunity to emerge as pests.

The physiological disorder of leaf reddening sparsely reported in the past had widespread area under Bt-cotton in rainfed areas. Since boll development is more synchronous in Bt-cotton the high demand for nutrients results into physiological disorders such as leaf reddening or senescence, square and boll shedding, parawilt or sudden wilt, bad opening of bolls, etc. Edreva and co-workers [5] reported that leaf

reddening was physiological disorder induced by different abiotic stresses that occurred due to biochemical changes in leaves; more accumulation of anthocynins and reduction of chlorophyll content, and increase in proline content and peroxidise activity. Strong inhibition of rates of CO_2 assimilation and transpiration, stomatal conductance, and water use efficiency as well as decreased photochemical activity and stomatal limitations are related to the severity of reddening [6].

Genetic makeup of the plant is very much important to overcome the adversaries of biotic stress due to sucking pests and physiological disorder like leaf reddening. In this context it was hypothesized that the plant genotype (Bt-cotton hybrids) have variable response to biotic stress such as reaction to sucking pests and abiotic stress especially to excess or deficit soil moisture, temperature, sunshine that impacted leaf reddening and it would be advantageous to select genetically tolerant cultivars to harness maximum possible yield through reduced damage. To test this hypothesis, evaluation of 54 Bt-cotton hybrids recommended for growing under rainfed farming conditions of Central India was carried out to provide the farmers with the option of selecting least susceptible cultivars to sucking pests and leaf reddening to avoid the economic losses.

Materials and Methods

Layout of experiment

An experiment was carried out at experimental field of Central Institute for Cotton Research; Nagpur (coordinates 21002'15.9"N, 79°03'08.8"E). A total 54 Bt-cotton hybrids (14 Bollgard+40 Bollgard II (BGII)) from 19 seed companies that contain cry1Ac (Mon 531), cry1Ac (JK Event 1), cry1Ac & cry2Ab (Mon 15985), GFM cry1A (cry1Ab+cry2Ac) (Table1) were sown in one hectare area in a Randomised Block Design with three replications. A single genotype block measured 6 m × 6 m with 100 plants. All recommended pre-sowing and post-sowing agronomical package of practices meant for rainfed cotton farming were followed.

S.No.	Name of Bt hybrid	Original hybrid	Gene incorporated	Seed company
1	Ankur 2104 BG II	Ankur 2104	cry1Ac & cry2Ab(Mon 15985)	Ankur seeds
2	Ankur 216 BG II	Ankur 216	cry1Ac & cry2Ab(Mon 15985)	
3	Ankur 257 BG II	Ankur 257	cry1Ac & cry2Ab(Mon 15985)	
4	Ankur 3028 BG	Ankur 3028	cry1Ac(Mon 531)	
5	Ankur 3034 BG II	Ankur 3034	cry1Ac & cry2Ab(Mon 15985)	
6	Ankur 3042 BG	Ankur 3042	cry1Ac(Mon 531)	
7	Ankur3070 BG II	Ankur 3070	cry1Ac & cry2Ab(Mon 15985)	
8	Ankur Jai BG II	Ankur Jai	cry1Ac & cry2Ab(Mon 15985)	
9	SP 504 BGII	SP 504	cry1Ac & cry2Ab(Mon 15985)	Bayer BioSci.
10	Durga BG	Durga	cry1Ac(JK Event 1)	J.K.Agri Gene.
11	Ishwar BG	JKCH 634	cry1Ac(JK Event 1)	
12	JKCH 99 BG	JKCH 99	cry1Ac(JK Event 1)	
13	Jack pot BG II	KCH 15 x 39	cry1Ac & cry2Ab(Mon 15985)	Kaveri Seed
14	MRC 7301 BG II	MRC 7301	cry1Ac & cry2Ab(Mon 15985)	Mahyco
15	MRC-7383 BG II	MRC 7383	cry1Ac & cry2Ab(Mon 15985)	
16	Atal BG II	Atal	cry1Ac & cry2Ab(Mon 15985)	Monsanto gene.
17	Express BG II	NCEH 14	GFM cry1A(cry1Ab + cry2Ac)	Nath Seed
18	Bunny BG II	NCS 145	cry1Ac & cry2Ab(Mon 15985)	Nuziveedu Seeds
19	Bunny BG	NCS 145	cry1Ac(Mon 531)	
20	Manjeet BG II	NCS 858	cry1Ac & cry2Ab(Mon 15985)	
21	Uttam BG II	NCS 860	cry1Ac & cry2Ab(Mon 15985)	
22	Superman BG II	NCS 861	cry1Ac & cry2Ab(Mon 15985)	
23	Dhanwan BG II	NCS 862	cry1Ac & cry2Ab(Mon 15985)	
24	Shrimanth BG	NCS 906	cry1Ac(Mon 531)	
25	Krishna BG II	NCS 909	cry1Ac(Mon 531)	
26	Mallika Gold BG II	NCS-859	cry1Ac & cry2Ab(Mon 15985)	
27	Vanaja BG	NCS-907	cry1Ac(Mon531)	
28	Kohinoor BG	NCS-908	cry1Ac(Mon531)	
29	Anvitha BG	NCS-910	cry1Ac(Mon 531)	
30	Madhura BG	PCH77	cry1Ac (JK Event1)	Palamoor Seed
31	Paras Brahma BG II	Paras Brahma	cry1Ac & cry2Ab(Mon 15985)	Paras Extra Growth
32	Paras Krishna BG II	Paras Krishna	cry1Ac & cry2Ab(Mon 15985)	
33	Classic BGII	PCH 882	cry1Ac & cry2Ab(Mon 15985)	Prabhat Agri biotech
34	Kanak BGII	PCH-881	cry1Ac & cry2Ab(Mon 15985)	
35	Menaka BG II	PRCH-331	cry1Ac & cry2Ab(Mon 15985)	Pravardhan seed
36	Mahi BG II	PRCH-333	cry1Ac & cry2Ab(Mon 15985)	
37	Aadhar BG	PRCH-405	cry1Ac(Mon531)	
38	Ryan BG	PRCH-712	cry1Ac (JK Event1)	

39	Alto BG II	RCH 377	cry1Ac & cry2Ab(Mon 15985)	Rasi Seeds
40	RCH 530 BG II	RCH 530	cry1Ac & cry2Ab(Mon 15985)	
41	Krish BG II	SWCH 4708	cry1Ac & cry2Ab(Mon 15985)	Seed Worker Intl. Pvt Ltd.
42	Mahadev BG II	SWCH 5017	cry1Ac & cry2Ab(Mon 15985)	
43	Veda 2 BG II	Solar 60	cry1Ac & cry2Ab(Mon 15985)	Solar Agrotech
44	Shivam BG II	Solar 66	cry1Ac & cry2Ab(Mon 15985)	
45	Namaskar BG II	Tulsi 117	cry1Ac & cry2Ab(Mon 15985)	Tulsi Seeds
46	Dyna BG II	Dyna	cry1Ac & cry2Ab(Mon 15985)	Vibha Seeds.
47	VICH 301 BG II	VICH 301	cry1Ac & cry2Ab(Mon 15985)	Vikram Seeds
48	VICH 303 BG II	VICH 303	cry1Ac & cry2Ab(Mon 15985)	
49	VICH 304 BG II	VICH 304	cry1Ac & cry2Ab(Mon 15985)	
50	VICH 311 BG II	VICH 311	cry1Ac & cry2Ab(Mon 15985)	
51	VICH 312 BG II	VICH 312	cry1Ac & cry2Ab(Mon 15985)	
52	VICH 313 BG II	VICH 313	cry1Ac & cry2Ab(Mon 15985)	
53	VICH 314 BG II	VICH 314	cry1Ac & cry2Ab(Mon 15985)	
54	Margo BG	YRCH 31	GFM cry1A (cry1Ab + cry2Ac)	Yashoda Hybrid Seeds

Table 1: Details of Bt-cotton hybrids tested for tolerance to sucking pest and leaf reddening

Protective plant protection measures

Two insecticidal sprays, first of Thiamethoxam 25%WG 0.2 gm/l at 78 days after sowing (DAS) and second of Acetamiprid 20 SP (0.2 gm/l) at 93 DAS to check rising population of sucking pests, and two fungicidal sprays (Carbendazim 50% WP (1 g/l) at 79 & 109 DAS against Alternaria disease were applied.

Data collection

Data on population dynamics of sucking pests were recorded at weekly intervals throughout the season. While insect counts of leafhoppers, whiteflies and thrips were taken from randomly selected 3 leaves (top, middle and bottom) mirid population was recorded from the whole 5 plant. Visual observation on leaf reddening was recorded at 108 DAS (bolls opening stage). More than 50% leaves on a plant turning red of 50% plant population was considered as susceptible hybrid for leaf reddening. Yield was recorded by measuring seed cotton from individual blocks and converted into kg/ha.

Statistical analysis

The data obtained were statistically analysed to find out the genetic tolerance of Bt-cotton hybrids with respect to sucking pests and yield potential. Data were subjected to analysis of variance under completely randomized design using online software Web Agri Stat Package 2.0 (ICAR Research Complex for Goa, Ila Old Goa, India). A significance level of $P<0.05$ was used to separate means using critical difference values.

Results

Bt-cotton hybrids tolerant to sucking pests

Leafhoppers: Significantly lowest population of leafhoppers (per 3 leaves) was recorded in Ankur 3070 BG II(1.93) and was on a par with Durga BG(2.01), Atal BG II(2.06), Krish BG II(2.19), Ryan BG(2.27), Madhura BG(2.39), MRC 7301 BG II(2.38), SP 504 BG II(2.60), Namskar BG II(2.62), Mahi BG II(2.65), VICH 312 BG II(2.76), Ankur 3028 BG(2.78), Anvitha BG(2.79), VICH 304 BG II(2.91), Ankur 3034 BG II(2.89), VICH 311 BG II(2.90), Ankur Jai BG II(2.95), Ankur 216 BG II(2.97), Ankur 3042 BG II(2.98), Vanaja BG(2.98), VICH 301 BG II(3.00), Classic BG II(3.03), Bunny BGII(3.08), Menaka BG II(3.07), VICH 314 BG II(3.08), Veda 2 BG II(3.17), VICH 303 BG II(3.20). Bt-cotton hybrids Dyna BG II(5.05), Paras Brahma BG II(5.06), RCH 530 BG II(5.17), Ankur 2104 BG II(5.44 per 3 leaves), Superman BG II(5.62) were found to be highly susceptible to leafhoppers. The remaining Bt-cotton hybrids were moderately tolerant.

Thrips: The lowest population of thrips was observed in Ankur 2104 BG II(0.14/3leaves) followed by Atal BG II(0.16), Madhura BG(0.19), Mahadev BG II (0.22), Anvitha BG(0.25), Mahi BG II(0.28), VICH 313 BG II(0.30),VICH 301 BG II(0.30), Kohinoor BG(0.31), SP 504 BG II(0.32), VICH 311 BG II(0.34), Krish BG II(0.35), Aadhar BG(0.36), Vanaja BG(0.38), Dyna BG II(0.38), Ankur 3070 BG II(0.39), Namskar BG II(0.41), Ishwar BG(0.41), Ryan BG(0.43), Bunny BG II(0.44), Superman BG II(0.44), MRC 7301 BG II (0.46), Ankur 257 BG II(0.46), Durga BG(0.47), Shrimanth BG(0.50),Classic BG II (0.54), Ankur 3034 BG II(0.55), VICH 312 BG II(0.57), Express BG II (0.60), Manjeet BG II (0.62), MRC-7383 BG II(0.63), Ankur Jai BG II(0.63), Menaka BG II (0.64), ALTO BG II (0.66), RCH 530 BG II(0.69), Ankur 3042 BG II(0.70), VICH 303 BG II(0.71), JKCH 99 BG(0.71). Thrips population was statistically identical in all the above Bt-cotton hybrids. While remaining Bt-cotton hybrids showed less tolerance to thrips (Figure 2).

Whitefly: Whitefly population did not show any significant variation in all the 54 Bt-cotton hybrids tested over the season.

Mirid bug: Mirid bug population was lowest and on par among JKCH 99 BG(0.35 mirids/plant), Ankur 3042 BG II (0.25), Menaka BG II (0.34), Mahadev BG II(0.36), Classic BG II(0.41), VICH 301 BG II(0.44), Ankur Jai BG II(0.42), Madhura BG(0.46), Veda 2 BG II(0.46) and Ryan BG(0.48). Moderate mirid population (in the range 0.52 – 0.89 mirids/plant) was recorded in Namskar BG II, VICH 314 BG II, Aadhar BG, MRC 7301 BG II , Kohinoor BG, VICH 312 BG II, Krish BG II, Vanaja BG, Atal BG II, Bunny BGII, Ankur 3028 BG, ALTO BG II, SP 504 BG II, VICH 303 BG II, Ankur 3070 BG II, Express BGII, Ankur 3034 BG II, VICH 311 BG II, Ankur 216 BG II, Ishwar BG, Superman BG II, Bunny BG, Krishna BG II, Shrimanth BG, Manjeet BG II, Ankur 257 BG II, Mallika Gold BG II, VICH 313 BG II. While remaining hybrids showed high susceptibility to mirids (Figure 3).

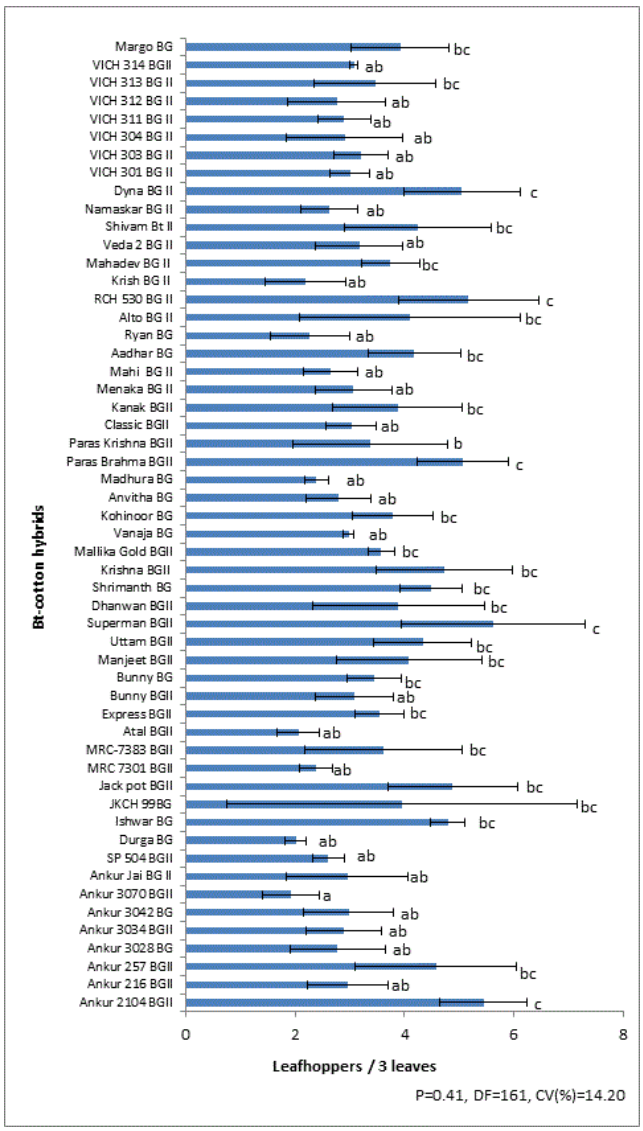

Figure 1: Leafhopper counts on Bt-cotton hybrids.

Bt-cotton hybrids tolerant to leafhoppers and thrips: Bt-cotton hybrids Ankur 3034 BG II, Ankur 3042 BG II, Ankur 3070 BG II, Ankur Jai BG II, Anvitha BG, Atal BG II, Bunny BG II, Classic BG II, Durga BG, Krish BG II, Madhura BG, Mahi BG II, Menaka BG II, MRC 7301 BG II, Namskar BG II, Ryan BG, SP 504 BG II, Vanaja BG, VICH 301 BG II, VICH 303 BG II, VICH 304 BG II, VICH 311 BG II and VICH 312 BG II were observed to be tolerant to both leafhoppers and thrips based on the comparative population levels.

Bt-cotton hybrids tolerant to leafhoppers and mirids: Among tested 54 Bt-cotton hybrids, Ankur 3042 BG II, Ankur Jai BG II, Classic BG II, JKCH 99 BG, Madhura BG, Mahadev BG II, Menaka BG II, Ryan BG and VICH 301 BG II were found tolerant to both leafhoppers and mirids.

Bt-cotton hybrids tolerant to all sucking pests: The cultivars which were found tolerant to all sucking pests under study (viz. leafhoppers, thrips and mirid bugs) were recorded as: Ankur 3042 BG II, Ankur Jai BG II, Classic BG II, Madhura BG, Menaka BG II, Ryan BG and VICH 301 BG II.

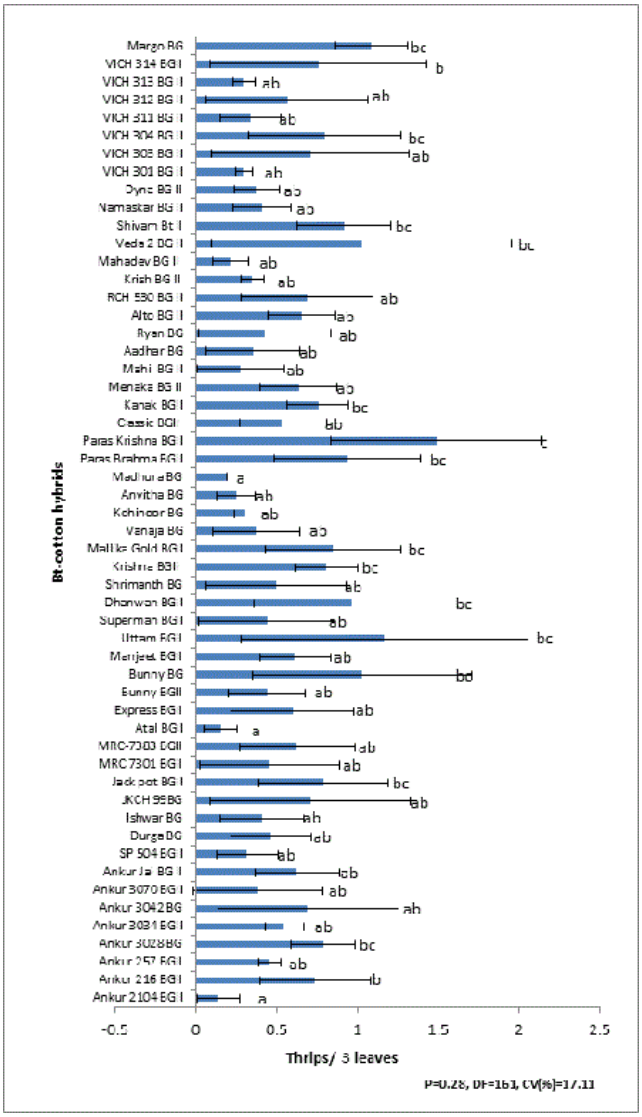

Figure 2: Thrips counts on Bt-cotton hybrids

Yield levels

The seed cotton yield differed significantly amongst the Bt-cotton hybrids (Figure 4). Maximum yield (Kg/ha) was obtained in MRC 7301 BG II(1955.48) and was similar to Krish BG II(1779), RCH 530 BG II(1765), Atal BG II(1741), Bunny BG(1666), Uttam BG II(1638), Classic BG II(1594), Shrimanth BG(1590), ALTO BG II(1583), Krishna BG II(1562) and Ryan BG(1539). Moderate yield was recorded in SP 504 BG II(1446), VICH 304 BG II(1445), Namskar BG II(1437), Madhura BG(1435), VICH 312 BG II(1422), Express BG II(1397), Dyna BG II(1394), VICH 313 BG II(1367), Ankur 257 BG II(1360), Mahadev BG II (1345), VICH 301 BG II(1337), VICH 314 BG II(1314), Jack pot BG II(1307), MRC 7383 BG II(1305), Ankur 3034 BG II(1283), Ankur Jai BG II(1261), Margo BG(1261), Ankur 3070 BG II(1214), Ankur 216 BG II(1203), Durga BG(1200), Veda 2

BG II (1181), Manjeet BG II(1137), VICH 303 BG II(1133), Shivam BGII (1125), JKCH 99 BG(1121), Anvitha BG(1083), Ankur 3028 BG(1079), Mahi BG II(1068), Vanaja BG(1050) and Mallika Gold BG II(1029).

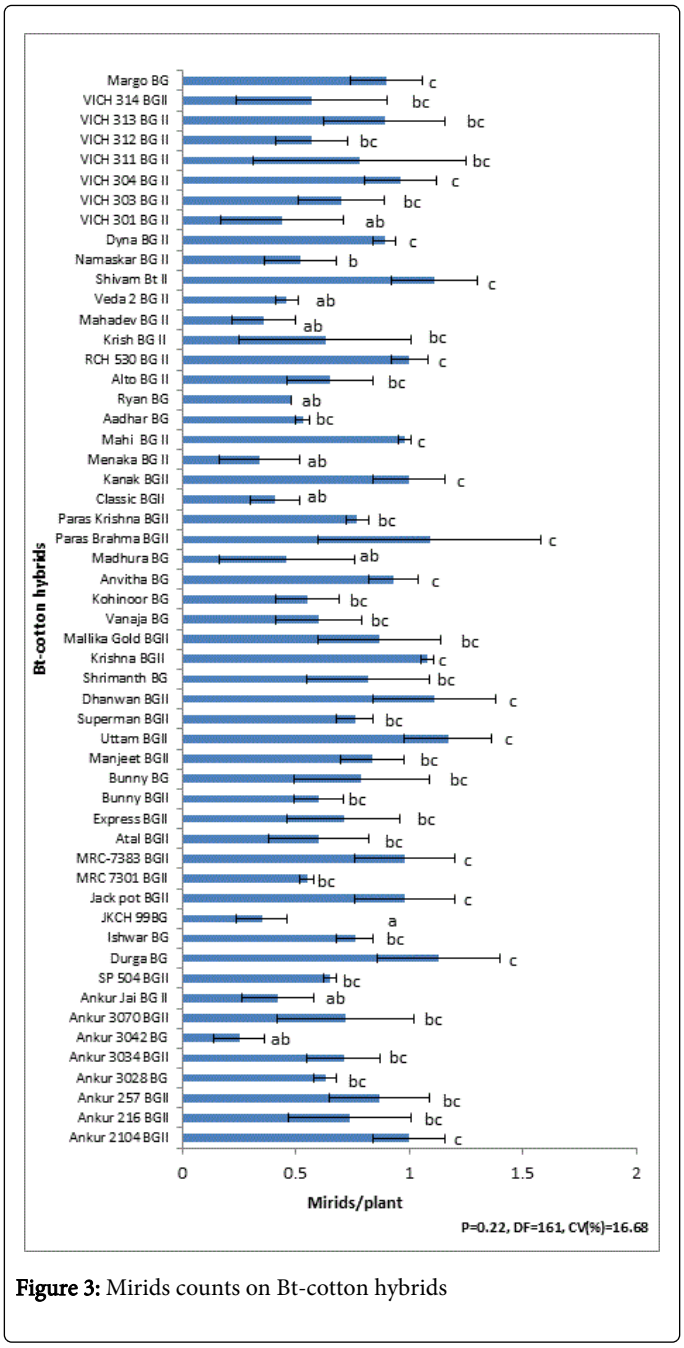

Figure 3: Mirids counts on Bt-cotton hybrids

Bt-cotton hybrids tolerant to leaf reddening

Visual observations recorded at 108 DAS (boll opening stage) indicated Ankur 216 BG II, Ankur 3042 BG II, Ankur Jai BG II, Atal BG II, Express BG II, MRC 7301 BG II, Paras Krishna BG II, Uttam BG II, VICH 303 BG II and VICH 304 BG II were unaffected by leaf reddening while remaining found to be susceptible (Table 2).

Discussion

It is well known fact that genetic makeup of genotype affects the response by pest and other stresses in a number of ways, including leaf curling, wilting, chlorosis or necrosis of photosynthetically active parts, stunted growth, or in some cases reduction in leaf area due to severe defoliation [7,8].

Leaf reddening	Bt-cotton hybrids
Tolerant (free from leaf reddening)	Ankur 216 BG II, Ankur 3042 BG II, Ankur Jai BG II, Atal BG II, Express BG II, MRC 7301 BG II, Paras Krishna BG II, Uttam BG II, VICH 303 BG II and VICH 304 BG II.
Susceptible (More than 50% leaves on a plant turning red of 50% plant population)	Aadhar 405 BG, Alto BG II, Ankur 2104 BG II, Ankur 257 BG II, Ankur 3028 BG II, Ankur 3034 BG II, Ankur 3070 BG II, Anvitha BG, Bunny BG II, Bunny BG, Classic BG II, Dhanwan BG II, Durga BG, Dyna BG II, Ishwar BG, Jack pot BG II, JKCH 99 BG, Kanak BG II, Kohinoor BG, Krish BG II, Madhura BG, Mahadev BG II, Mahi BG II, Mallika Gold BG II, Manjeet BG II, Margo BG, Menaka BG II, MRC7383 BG II, Namaskar BG II, Paras Brahma BG II, RCH 530 BG II, Ryan BG, Shivam BG II, Shrimanth BG, SP 504 BG II, Superman BG II, Vanaja BG, Veda 2 BG II, VICH 301 BG II, VICH 311 BG II, VICH 312 BG II, VICH 313 BG II,

Table 2: Performance of Bt-cotton hybrids against leaf reddening

The results indicated that 54 Bt-cotton hybrids under evaluation expressed varied response to sucking pests. The degree of incidence varied from genotype to genotype. Khan [9] reported that the cultivars having higher hair density were found resistant and cultivars having lower hair density were susceptible to leafhoppers. Some of hybrids might bear the higher density which need be investigated.

Our results also revealed that Ankur 216 BG II, Ankur 3042 BG II, Ankur Jai BG II, Atal BG II, Express BG II, MRC 7301 BG II, Paras Krishna BG II, Uttam BG II, VICH 303 BG II and VICH 304 BG II were unaffected by leaf reddening while remaining were found to be susceptible. It clearly indicated that genotype behaved differently on same piece of land exposed to similar environmental adversities and it is firmly believed that it is related to genetic makeup of the genotypes. Though other reasons like cloudy weather, water deficit or water logging stress, high temperature, etc [10] may have contribution in leaf reddening.

None of the Bt hybrid scored full score with respect to all parameters (6) under study but MRC 7301 BG II, Atal BG II, Classic BG II, Krish BG II, Ryan BG, SP 504 BG II, Namskar BG II, Madhura BG, VICH 312 BG II performed better with lower population levels of sucking pest, lesser leaf reddening and higher yield levels. Cotton stakeholders must opt for tolerant genotypes to reduce the use of insecticidal sprays in cotton agroecosystem, to save input costs and to maintain ecological balance by conserving natural enemies. Use of tolerant genotypes should be an important component while formulating the IPM strategies.

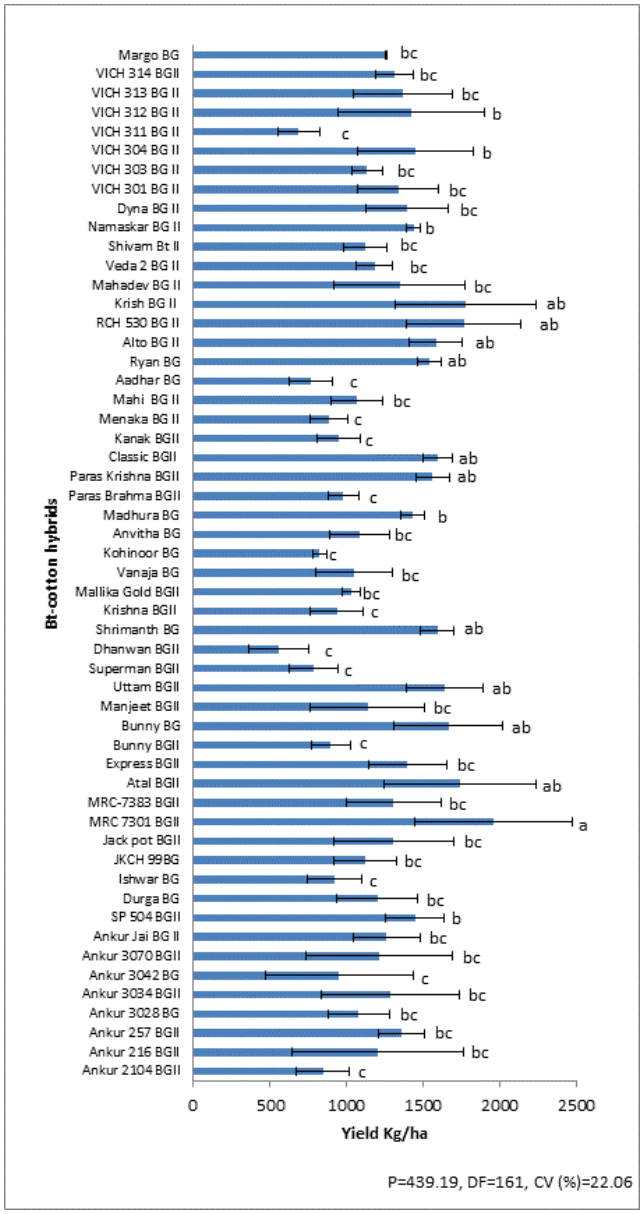

Figure 4: Yield performance by different Bt-cotton hybrids

Acknowledgements

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