J. Cotton Res. Dev. **31** (1) 108-115 (January, 2017)

Performance of *Bt* cotton hybrids and their counterparts under IPM in rainfed condition of Vidarbha region

A. V. KOLHE*, JAYASHRI UGHADE AND D.B.UNDIRWADE

University Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola- 444 104

**E mail: avkolhe@gmail.com*

ABSTRACT: The comprehensive pest management module was evaluated against major pests of popular *Bt* cotton hybrids (RCH 2 *Bt,* Bunny *Bt* and KDCH 9632 *Bt*), their non *Bt* counterpart and PKV Hy 2 (local check) at 3 locations of western Vidarbha (Akola, Yavatmal and Amravati) under the jurisdiction of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during *kharif,* 2008, 2009 and 2010. The results revealed that PKV Hy 2 harboured lowest leafhoppers (1.35/leaf), whereas, RCH 2 *Bt* carries highest leafhoppers (2.29/leaf). Population of bollworms and their damage was significantly lower in *Bt* hybrids as compared to their non *Bt* counterpart. Against sucking pests, higher quantity of insecticides (g a. i./ha) was consumed by *Bt* hybrids (43.35 to 51.60) and their non *Bt* counterparts (43.35 to 48.30) over local check, PKV Hy 2 (34.95), which was 19.38 to 32.27 and 14.87 to 18.88 per cent higher than PKV Hy 2, respectively. Against bollworms, protection was not required in *Bt* hybrids, hence, there was a saving of 68.39 to 72.22 per cent chemical insecticides over non *Bt* counterparts. Significantly higher seed cotton yield and incremental cost benefit ratio was obtained in Bunny *Bt* and KDCH 9632 *Bt* than rest of the hybrids tested. About 29.93 to 45.35 per cent higher output and 36.70 to 63.14 per cent net profit in *Bt* cotton hybrids was recorded over non *Bt* hybrids.

Key words : Bollworms, *Bt* cotton, IPM, predators, sucking pests

Genetically modified cotton was commercialized in India during 2002 with an area of about 50,000 ha and presently covered more than 90 per cent of the total area of cotton in the country. Transgenic cotton offered a protection to all 3 kinds of bollworms and It also exhibits high level of safety to non-target organisms (Manjunath, 2011). *Bt* cotton hybrids with six events commercialized by more than 35 seed companies in India. Hence, the cotton farmers have choice for selection of best performing *Bt* hybrids (James, 2010).

However, high yielding *Bt* cotton hybrids with glabrous leaves are susceptible to leafhoppers *(Amrasca biguttula biguttula* Ishida), while hybrids with non glabrous leaves succumb to whitefly *(Bemesia tabaci* Gennadius) attack. The pests like, aphids *(Aphis gossypii),* and thrips *(Thrips tabaci* Lind) also cause economic loss to the crop. As a consequence of this, insecticide usage which had declined from Rs. 26223 million in 2002 to Rs. 24388 million in 2005, increased to Rs. 76836 million by 2010 (Anonymous, 2011).

Commercialization of *Bt* cotton indicated that the technology is not a panacea for all the pests instead integrated approach would be necessary to draw maximum benefits and to sustain the technology. With its intrinsic resistance to bollworms, *Bt* cotton become an ideal component for IPM. Hence, effort has been made to evaluate the performance of different *Bt* cotton genotypes and their non *Bt* counterparts under the umbrella of IPM and to work out cost benefit under rainfed condition.

MATERIALS AND METHODS

IPM module was evaluated on popular *Bt* cotton hybrids (RCH 2 *Bt,* Bunny *Bt* and KDCH 9632 *Bt)* as well as their non *Bt* counterpart and PKV Hy 2 as local check during *kharif,* 2008 to 2010 at 3 locations *viz.,* Akola, Yavatmal and Amravati. Besides plant protection measures all recommended agronomic practices were followed at each location. The experiment was laid out in randomised block design with 3 replications with each block of 6.3 x 5.4 m. The hybrids were sown at 90 x 60 cm spacing.

The following IPM module was used under each hybrid. Seed treatment with imidacloprid 70 WS @10 g/ kg seed, ETL based spray of acetameprid 20 SP @ 15 g a. i. /ha for sucking pests, 2 releases of *Trichogramma chilonis* @1.5 lakh /ha at 45 -50 and 55-60 days after emergence for bollworm, ETL based sprays of *Azadirachtin* 300 ppm and spinosad 45 SC against bollworms, sowing of 2 rows of cowpea around each treatment plot, collection and destruction of spotted bollworm infested shoots along with larvae, big size *H. armigera* larvae and rosette flowers, installation of yellow sticky traps for whiteflies (1 trap / plot) were followed.

To ascertain the ETL of particular pest, weekly observations on pests were recorded accordingly foliar sprays of chemical insecticides were undertaken as and when ETL reached. Other practices were carried out as per the need and stage of crop.

Observations were recorded at weekly interval by randomly selecting 5 plants from each plot. Population of sucking pests (aphids, leafhoppers, thrips, and whiteflies)/plant on 3 leaves (each from top, middle, bottom canopy of plant) was counted and average population/ leaf was computed. Population of predators *(Chrysopa* larvae, lady bird beetles adults and grubs and spiders collectively) *H. armigera* and *P. gossypiella* larvae was recorded on whole plant. Damage by bollworm complex in green fruiting bodies (squares, flowers and green bolls) was recorded by counting total green fruiting bodies and that damage by bollworms on randomly selected plant. Pink bollworm damage and larval population in green bolls observed after dissecting green bolls on plant at 120 and 135 days after emergence. Twenty green mature bolls of same size were randomly plucked from border rows of every plot for recording the observation on pink bollworm. Bollworm damage in open bolls and loculi was recorded at harvest by randomly selecting 5 plants from each plot and 3 bolls from top, middle and bottom canopy of each plant were plucked and observed for bollworm complex damage. Yield of seed cotton at each picking was also recorded. Data during 3 years across the 3 locations was analysed and presented.

RESULTS AND DISCUSSION

Sucking pests: Minimum aphid population (2.75/leaf) was noticed in KDCH 9632 *Bt* and it was *on par* with RCH 2 *Bt,* Bunny non *Bt ,* RCH 2 non *Bt* and Bunny *Bt* (Table 1). KDCH 9632 non *Bt* recorded highest aphids (4.79/leaf) and it was *on par* with PKV Hy 2. Lowest population of leaf hopper (1.35/leaf) was recorded in PKV Hy 2 and being *on par* with Bunny non *Bt.* KDCH 9632 *Bt* and non *Bt* ranked second followed by Bunny *Bt* which was *on par* with RCH 2 non *Bt.* RCH 2 *Bt* recorded highest (2.29/leaf) leafhopper population and proved to be most susceptible hybrid. Bunny *Bt* and RCH 2 *Bt* observed significantly higher population

Table 1. Average population of sucking pests, predators and bollworms in various *Bt* and non *Bt* hybrids

Hybrids	Aphids/ leaf	Leaf hopper/ leaf	Thrips/ leaf	Whitefly adults/ leaf	# Predator/ plant	*H. armigera* larvae/ plant	Pink bollworm larvae/ boll
RCH 2 *Bt*	2.91 (1.70)* a	2.29 (1.51)* cd	1.56 (1.25)*	2.02 (1.42)*	1.16 (1.08)** b	0.05 (0.74)** a	0.09 (0.77)** a
RCH 2 non *Bt*	2.98 (1.72) a	2.02 (1.42) bc	1.65 (1.28)	2.09 (1.45)	0.92 (0.96) a	0.18 (0.82) ab	0.79 (1.14) cd
Bunny *Bt*	2.98 (1.73) a	1.94 (1.39) bc	1.85 (1.36)	2.20 (1.48)	1.24 (1.11) b	0.04 (0.73) a	0.19 (0.83) a
Bunny non *Bt*	2.91 (1.71) a	1.53 (1.24) a	1.72 (1.31)	2.05 (1.43)	1.02 (1.01) a	0.30 (0.89) c	0.68 (1.08) c
KDCH 9632 *Bt*	2.75 (1.66) a	1.78 (1.33) ab	1.99 (1.41)	2.22 (1.49)	1.34 (1.16) b	0.07 (0.76) ab	0.12 (0.79) a
KDCH 9632 non *Bt*	4.79 (2.18) bc	1.62 (1.27) ab	1.76 (1.33)	2.19 (1.48)	1.07 (1.03) a	0.34 (0.92) c	0.63 (1.06) c
PKV Hy 2 (local check)	4.07 (2.01) b	1.35 (1.16) a	1.80 (1.34)	2.41 (1.55)	1.17 (1.08) b	0.30 (0.89) c	0.26 (0.87) ab
C.D. (p=0.05)	0.23	0.10	-	-	0.10	0.08	0.06
C.V. (%)	7.28	4.21	4.89	3.30	5.43	5.17	3.68

*square root values, ** square root of x + 0.5 # Predator includes lady beetle adult and grub, chrysopa larvae, syrphid larvae and spiders. Same letter indicated statistically equal treatment

of leafhoppers as compared to its non *Bt* counterpart, however, KDCH 9632 *Bt* was equal with its non *Bt* counterpart. Population of thrips and whitefly adult was statistically similar in various cotton hybrids tested. These results are in agreement with the findings of Kolhe *et al.,* (2012) who revealed highest susceptibility of RCH 2 *Bt* to leafhoppers which contributes major share of loss in seed cotton yield, however, Shera *et al.,* (2014) Phulse and Udikeri (2014) and Kaur *et al.,* (2016) who reported by enlarge equal population of sucking pests on *Bt* and non *Bt* hybrids.

Predators: Significantly higher predators population (lady bird beetle adults and grubs, *Chrysopa* and syrphid larvae and spiders) was recorded in KDCH 9632 *Bt* (1.16/ plant) and *on par* with Bunny *Bt,* PKV Hy 2 and RCH 2 *Bt* (Table 1). Lowest predator population were noticed in RCH 2 non *Bt* (0.96/plant) and being *on par* with Bunny non *Bt* and KDCH 9632 non *Bt.* The presence of higher predators on *Bt* cotton is due to reduction in sprays, insecticide quantity and exposure period as compared to their non *Bt* counterparts. These findings are in line with study conducted by Dhawan *et al.*, (2011) and Kumar *et al.*, (2011).

Population of bollworms and their damage: The data presented in Table 1 revealed that the population of *Helicoverpa armigera* and pink bollworm larvae in *Bt* cotton hybrids was *on par* (0.04-0.07/plant and 0.09 to 0.19/boll, respectively) and significantly lower than non *Bt* hybrids (0.18-0.34/plant and 0.26 to 0.68/boll, respectively). Highest population of *H. armigera* larvae was recorded in KDCH 9632 non *Bt* and pink bollworm larvae in Bunny non *Bt.* The results revealed that all

Table 2. Bollworm damage in various *Bt* and non *Bt* hybrids

Hybrids	Green fruiting bodies damage (%)		Open boll damage due to BWC at harvest (%)	Loculi damage at harvest (%)	
	BWC	PBW		BWC	PBW
RCH 2 *Bt*	0.92(0.96)* b	4.89(2.21)* a	2.37(1.51)* a	0.95(1.19)* a	0.54(1.02)* b
RCH 2 non *Bt*	2.95(1.71) cd	13.51(3.67) b	14.77(3.84) b	7.77(2.87) b	4.10(2.14) de
Bunny *Bt*	0.61(0.78) a	4.53(2.12) a	1.60(1.26) a	0.70(1.09) a	0.31(0.90) a
Bunny non *Bt*	3.52(1.88) e	12.22(3.49) b	14.55(3.81) b	6.84(2.69) b	3.57(2.02) de
KDCH 9632 *Bt*	0.55(0.74) a	3.67(1.91) a	1.80(1.33) a	0.30(0.89) a	0.24(0.86) a
KDCH 9632 non *Bt*	2.56(1.60) c	12.80(3.57) b	13.07(3.60) b	6.04(2.54) b	2.60(1.76) c
PKV Hy 2 (localcheck)	3.07(1.75) cd	12.04(3.47) b	14.11(3.72) b	6.09(2.54) b	3.19(1.92) d
C.D. (p=0.05)	0.12	0.36	0.66	0.48	0.14
C.V. (%)	5.02	6.85	13.71	13.71	5.07

*Square Root Values , BWC- Bollworm Complex, PBW- Pink Bollworm, Same letter indicated statistically equa treatment

Bt cotton hybrids exhibited significant reduction in bollworm infestation as against non *Bt* indicating the superiority of transgenic *Bt* cotton. These findings are also endorsed by Gujar *et al.,* (2011) and Nadaf and Goud (2015).

The data presented in Table 2 indicated that the bollworm complex damage in green bodies was significantly lower in *Bt* cotton hybrids (0.55 to 0.92%) than non *Bt* hybrids (2.56 to 3.52 %). Maximum damage was recorded in Bunny non *Bt* followed by PKV Hy 2. Similarly, pink bollworm damage in green bolls in *Bt* cotton hybrids was *on par* (3.67 to 4.89%) and significantly lower than non *Bt* hybrids (12.04 to 13.51%). Highest pink bollworm damage in green bolls was recorded in RCH 2 non *Bt* and being *on par* with Bunny non *Bt* and PKV Hy 2. *Bt* genotypes recorded lower population of bollworms compared to non *Bt* hybrids with IPM tactics indicating the effectiveness of *Bt* toxin against bollworm. These results are matching with the findings of Shera *et al.,* (2014) and Nadaf and Goud (2015).

Minimum open boll (1.60 %) and loculi damage (0.30 %) due to bollworm complex at harvest was noticed in Bunny *Bt and* KDCH 9632 *Bt,* respectively and it was *on par* with rest of the *Bt* hybrids. Such damage in KDCH 9632 non *Bt* ranked 2nd and *on par* with PKV

Table 3. Number of insecticidal sprays and insecticide consumption in various *Bt* and non *Bt* hybrids

Hybrids	Number of spray			Insecticide consumption (g a.i./ha)			Total saving of insecticide over non *Bt* counterpart (%)	Per cent Increase in consumption of insecticide over PKV Hy 2	
	Sucking pests	Bollworms	**Total**	Sucking pests	Bollworms	**Total**		Sucking pests	Bollworms
RCH 2 *Bt*	3.33	0.00	**3.33**	49.95	0.00	**49.95**	68.97	30.03	0.00
RCH 2 non *Bt*	3.22	2.22	**5.44**	48.30	112.67	**160.97**	—	27.64	14.87
Bunny *Bt*	3.44	0.00	**3.44**	51.60	0.00	**51.6**	68.39	32.27	0.00
Bunny non *Bt*	3.00	2.33	**5.33**	45.00	118.25	**163.25**	—	22.33	18.88
KDCH 9632 *Bt*	2.89	0.00	**2.89**	43.35	0.00	**43.35**	72.22	19.38	0.00
KDCH 9632 non *Bt*	2.89	2.22	**5.11**	43.35	112.67	**156.02**	—	19.38	14.87
PKV Hy 2(local check)	2.33	1.89	**4.22**	34.95	95.92	**130.87**	—	0.00	0.00

Hy 2 , Bunny non *Bt* and RCH 2 non *Bt.* However, loculi damage due to *P. gossypiella* at harvest was lowest (0.24 %) in KDCH 9632 *Bt* and it was *on par* with Bunny *Bt* followed by RCH 2 *Bt,* KDCH 9632 non *Bt.* Highest loculi damage due to *P. gossypiella* at harvest was recorded RCH 2 non *Bt* (4.10 %) followed by Bunny non *Bt* and PKV Hy 2 being equal.

The lower incidence of bollworms and fruiting body damage across the *Bt* genotypes in IPM modules, certainly convinced the suitability of *Bt* genotype as critical component of IPM. Such performance of *Bt* genotypes under protected conditions are in accordance with those reported by Kolhe *et al.,* (2011) and Hallad *et al.,* (2014)

Number of insecticidal sprays and insecticide consumption : *Bt* cotton have inbuilt resistance to bollworms, so the chemical insecticides sprays were applied only for sucking pests. Among the *Bt* cotton hybrids lowest spray were required to KDCH 9632 *Bt* (2.89) and it was followed by RCH 2 *Bt* (3.33) and Bunny *Bt (3.44).* An average of 2.22 to 2.33 additional sprays were required for its non *Bt* counterpart to offer protection against bollworms. Among the non *Bt,* lowest sprays against sucking pests and bollworms (2.33 and 1.89, respectively) were applied in PKV Hy 2 followed by RCH 2 non *Bt* , Bunny non *Bt* and KDCH 9632 non *Bt* (2.89 to 3.22 and 2.22 to 2.33, respectively). RCH 2 *Bt* and Bunny *Bt* consumed higher sprays against sucking pests as they harbour higher leafhopper population over its non *Bt* counterpart, however, KDCH 9632 *Bt* required equal protection against sucking pest over its non *Bt* counterpart.

The total sprays of chemical insecticides in *Bt* and their non *Bt* counterpart was ranging from 2.89 to 3.44 and 5.11 to 5.44 respectively, which means there is a saving of about 2 chemical insecticides sprays on *Bt* cotton in Vidarbha region. These findings are also matched with the study conducted by Sadashivappa (2009) a who reported 3.29 to 4.60 and 3.77 to 7.22 spray of chemical insecticides in *Bt* and non *Bt* hybrids, respectively.

Against sucking pests, lowest quantity of insecticides (g a.i./ha) was required in PKV-Hy 2, local check (34.95) followed by KDCH 9632 *Bt* and non *Bt* (43.35), Bunny non *Bt* (45.00), RCH 2 non *Bt* (48.30), RCH 2 *Bt* (49.95) and Bunny *Bt* (51.60). Higher quantity of insecticides was required against sucking pests in *Bt* hybrids (RCH 2 *Bt* and Bunny *Bt)* as compared to its non *Bt* counterpart, however, it is equal in KDCH 9632 *Bt* and its non *Bt* counterpart. *Bt* cotton hybrids (RCH 2, Bunny and KDCH 9632) required 19.38 to 32.27 per cent higher insecticides against sucking pest as compared to PKV Hy 2. Against bollworms, lowest quantity of insecticides consumed in PKV Hy 2 (95.92) followed by KDCH 9632 non *Bt* (112.67), RCH 2 non *Bt* (112.67) and Bunny non *Bt* (118.25), hence, RCH 2 non *Bt,* Bunny non *Bt* and KDCH 9632 non *Bt* consumed 14.87 to 18.88 per cent higher insecticides as compared to PKV Hy 2. Overall 68.39 to 72.22 per cent saving of insecticides in *Bt* cotton over their non *Bt* counterparts were noted.

Many workers reported that the deployment of transgenic insect resistant crops has made a significant contribution in reducing the quantity and frequency of insecticides application and yield losses due to bollworms (Dhawan *et al.,* 2011, Ashok *et al.,* 2012 and Kumar *et al.,* 2015).

Plant protection cost: The cost of plant protection in *Bt* and their non *Bt* counterpart

Table 4. Seed cotton yield and cost economics in various *Bt* and non *Bt* hybrids

Hybrids	Seed cotton yield (q/ha)	Gross return (Rs/ha)	Out put over non *Bt* (%)	Cost of seed	Addit -ional cost of *Bt* seed over non *Bt* (Rs/ha)	Plant prote- ction cost (Rs/ ha)	Total plant protection cost including additional cost of *Bt* seed (Rs/ha)	Net return (Rs/ ha)	Net profit over non *Bt* (%)	ICBR
RCH 2 *Bt*	10.48	31440	45.35	5250	3225	2019	5244	26196	63.14	5.00
RCH 2 non *Bt*	7.21	21630	—	2025	—	5573	5573	16057	—	2.88
Bunny *Bt*	13.09	40579	34.26	5250	3225	2033	5258	35321	41.82	6.72
Bunny non *Bt*	9.75	30225	—	2025	—	5320	5320	24905	—	4.68
KDCH 9632 *Bt*	12.33	36990	29.93	5250	3225	1598	4823	32167	36.70	6.67
KDCH 9632 non *Bt*	9.49	28470	—	2025	—	4939	4939	23531	—	4.76
PKV Hy 2 (localcheck)	10.26	30780	—	1575	—	5245	5245	25535	—	4.87
C.D. (p=0.05)	1.01	3044					399.58	3195		0.87
C.V. (%)	5.48	5.44					4.32	6.84		9.59

Average cost of seed cotton @ Rs. 3000/q. Bunny- Rs. 3100/q

(Rs. 4939 to 5573/ha) is equal with each other (Table 4). Since, *Bt* seed is a component of IPM, it's additional seed cost over non *Bt* seed is considered as plant protection cost, as it save chemical insecticides against bollworms on *Bt* cotton. The cost of *Bt* seed is Rs. 5250/ha. The difference in the seed cost over non *Bt* seed was also reported by Ashok *et al.,* (2012) in Maharashtra and higher plant protection cost in non *Bt* over *Bt* hybrids.

Seed cotton yield and incremental cost benefit ratio: Highest yield of seed cotton (13.09 q/ha) was obtained in Bunny *Bt* and it was *on par* with KDCH 9632 *Bt* (12.33 q/ha). RCH 2 *Bt* ranked 2nd and being *on par* with PKV Hy 2, Bunny non *Bt* and KDCH 9632 non *Bt* (Table 4). Lowest yield (7.2 1q/ha) was recorded in RCH 2 non *Bt.* These results are in agreement with the findings of Sadashivappa (2009), Kolhe *et al.,(20* 11) Ashok *et al.,* (2012) and Shera *et al.,* (2014) who reported higher seed cotton yield in *Bt* cotton hybrids compared to non *Bt.*

Highest gross return was obtained from Bunny *Bt* (Rs. 40579/ha) followed by KDCH 9632 *Bt* (36990/ha). RCH 2 *Bt* stood third and being *on par* with PKV Hy 2, Bunny non *Bt* and KDCH 9632 non *Bt.* Lowest gross monetary return was obtained from RCH 2 non *Bt* (Rs. 21630/ha). About 29.93 to 45.35 per cent higher output was registered in *Bt* hybrids over non *Bt* counterparts. Highest net monetary return was obtained from Bunny *Bt* (Rs.3532 1/ha) and being equal with KDCH 9632 *Bt* and superior to remaining hybrids. RCH 2 *Bt* ranked second and being equal to PKV Hy 2, Bunny non *Bt,* and KDCH 9632 non *Bt.* Lowest net monetary return was recorded from RCH 2 non *Bt.* However, about 36.70 to 63.14 per cent net profit in *Bt* hybrids was registered over non *Bt* hybrids.

Highest incremental cost benefit ratio (ICBR) was obtained in Bunny *Bt* (1:6.72) and it was *at par* with KDCH 9632 *Bt* and these hybrids were superior to the rest of the hybrids. RCH 2 *Bt* was next in recording ICBR and being equal to the PKV Hy 2, KDCH 9632 non *Bt* and Bunny non *Bt.* The lowest ICBR was noted RCH 2 non *Bt (1:2.88).*

The higher output of 37 and net profit

of 89 per cent in *Bt* cotton in India over non *Bt* was recorded by Sadashivappa (2009). Similarly Bhute *et al.*, (2015) reported higher incremental cost benefit ratios (1 : 1.76 to 1 : 7.40) in *Bt* hybrids in various IPM modules. Hence, these findings are in the agreement with the present investigations.

ACKNOWLEDGEMENTS

Authors are highly acknowledge to the Senior Research Scientist (Cotton), Cotton Research Unit and Director of Research, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola for the financial support and facility.

REFERENCES

Anonymous, 2011. Vision 2030. Central Institute for Cotton Research, PB No. 2, Shankarnagar , Nagpur- 440 010, www.cicr.org.in. pp 10-19.

Ashok, K.R., Uma, K., Prahadeeswaran, M. and Jeyanthi, H. 2012. Economic and Environmental impact of *Bt* cotton in India. *Indian. J. Agric. Econ.,* **67** : 405-28.

Bhute, N. K., Bhosle, B. B. and More, D. G. 2015. Evaluation of integrated pest management modules in *Bt* cotton (*Gossypium hirsutum* L.) for major sucking pests in Marathwada region *J. Cotton Res. Dev.,* **29 :** 277-86.

Dhawan, A.K., Kumar, Vijay, Singh, Jasbir, Singh, Amardip and Singh, Amrik. 2011. Impact of adoption of insecticide resistance management strategies in irrigated *Bt* cotton in Punjab. *J. Cotton Res. Dev.,* **25** : 263-68.

Gujar, G.T., Bunkar, G.K., Sing, B.P. and Kalia, V. 2011. Field performance of F1-F2 and non *Bt* of BTI (MRC 7017 *Bt* and JKCH 1947 *Bt*) against bollworms of cotton. In *World Cotton Research Conference,* November 7-11, 2011 at The Renaissance Hotel and Convention Centre, Mumbai, India. Pp.165-73

Hallad, Anand V., Udikeri, S.S., Patil, S.B. and Bhat A.R.S. 2014. Field performance of first and second generation *Bt* cotton events for bollworm resistance in rainfed ecosystem. *Int. J. Curr. Micro biol. App. Sci.,* **3**:223-38.

James, Clive. 2010. Global status of commercialized biotech/GM crops : 2010. The International Service for the Acquisition of Agri-biotech Applications (ISAAA) , Ithaca, New York, USA. **42**:1-279

Kolhe, A.V., Barkhade, U.P., Zade, P.N. and Patil, B.R. 2012. Evaluation of popular *Bt* and non *Bt* transgenic cotton hybrids against major pests. In Silver Jubilee International Symposium on *"Global Cotton Production Technologies vis-à-vis Climate Change",* held during 10-12 Oct., 2012 at CCS Haryana Agriculture University, Hisar, pp. 333-37.

Kolhe, A.V., Patil, B.R. and Bhongle, S.A. 2011. Bio evaluation of *Bt* cotton hybrids against bollworm complex under rainfed conditions. *J. Cotton Res. Dev.,* **25**:282-86.

Kaur, Amardeep, Kumar, Vijay and Dhawan, A.K. 2016. Field reaction of transgenic cotton to sucking insect pest in north India. *J. Cotton Res. Dev.,* **30 :** 229-34.

Kumar, Rishi, Monga, D., Nitharwal Mukesh, Jat S.L. and Kumar, Kishor Chand. 2011. Validation of Eco friendly Integrated Pest Management packages in *Bt* cotton at farmer's participatory field, *J. Cotton Res. Dev. ,* **25 :** 243-47.

Kumar, Rishi, Monga, D., Nitharwal, Mukesh, Swami, Dinesh, Singh, Satnam 2015. Incidence of non target pest species and validation of IPM strategies in *Bt* cotton hybrids deployed with different events of cry genes, *Indian J. Agric. Sci.,* **85** : 115-19

Manjunath, T.M. 2011. Safety of *Bt* cotton: Facts allay Fear. A newsletter*Agbioworld,* Professor C.S. Prakash, AgBioWorld Foundation, Auburn, Alabama, P.O. Box 85 Tuskegee Insitute, AL 36087-0085, USA.(www.agbioworld.org/ biotech-info / articles/biotech-art/ index.html)

Nadaf, Abdul Rahaman, M and Goud, K Basavana 2015. Performance of*Bt* and non *Bt* cotton hybrids against pink bollworm, *Pectinophora gossypiella. Indian J. Pl. Prot.,* **43 :** 434-38

Phulse, V.B. and Udikeri, S.S. 2014. Seasonal incidence of sucking insect pests and predatory arthropods in *deshi* and *Bt* transgenic cotton. *Karnatka J. Agric. Sci.,* **27 :** 28-31.

Shera, P. S., Sohu, R. S., Gill, B. S., Sekhon, P. S. and Sarlach, R. S. 2014. Relative Performance of different *Bt* cotton cultivars expressing single and dual toxin for pest infestation, yield and fibre quality parameters. *Vegetos,* **27 :** 237-43

Sadashivappa, Prakash 2009. *Bt* Cotton in India: Development of benefits and the role of government seed price interventions. *AgBioForum*, **12 :** 172-83.

Received for publication : July 25, 2015
Accepted for publication : December 12, 2015