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Development of integrated pest management technology for *Bt* cotton under rainfed ecosystem

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ABSTRACT : Integrated pest management (IPM) module was developed and evaluated for *Bt* cotton at Jeerigiwad village during 2008-2009 and 2009-2010. The performance of *Bt* IPM module was compared with *Bt* cotton grown under recommended plant protection (RPP) and non *Bt* IPM. Whereas *Bt* RPP module involved use of selective insecticides for both sucking pests and bollworms control. Results revealed that low population of sucking pests was recorded in IPM blocks of both *Bt* and non *Bt* as compared to *Bt* RPP. *Bt* IPM registered 0.22 and 0.15 larvae of *Helicoverpa armigera* /plant as compared to 0.29 and 0.19 larvae/plant in *Bt* RPP and 0.72 and 0.85 larvae/plant in non *Bt* IPM during 2008-2009 and 2009-2010, respectively. Fruiting body damage was restricted to 3.57 and 2.73 per cent in *Bt* IPM compared to 3.75 and 2.81 per cent and 6.31 and 7.12 per cent in *Bt* RPP and non *Bt* IPM, respectively. Similar trend with respect to pink bollworm incidence across the genotypes and modules was observed. *Bt* genotypes with IPM intervention registered higher seed cotton yield of 25.92 and 25.20q/ha as compared to 23.90 and 24.85q/ha in *Bt* RPP and 21.40 and 21.50q/ha in non *Bt* IPM during 2008-2009 and 2009-2010, respectively with a net return of Rs. 61350 and Rs.73803 in *Bt* IPM as compared to Rs. 55403 and Rs. 72393 and Rs. 43633 and Rs. 55003 in *Bt* RPP and non *Bt* IPM.

Key words: *Bt* IPM, non *Bt* IPM, pest incidence, RPP, seed cotton yield

Transgenic *Bt* cotton genotypes expressing Cry1Ac endotoxin are found to be resistant to bollworms. With the adoption of *Bt* cotton cultivars it was expected to ensure favorable ecological, economical and sociological benefits. But after large scale adoption, a change in pest scenario has been observed, especially sucking pests and diseases assumed major status as the Cry1Ac affords protection only for lepidopteran pests (Dhaliwal *et al.,* 2010). The feedback since the commercialization of *Bt* cotton indicated that, the technology is not a panacea for all pest problems and integrated approach would be necessary to draw maximum benefit and to sustain the technology (Bambawale *et al.,* 2010). The IPM modules developed at ARS, Dharwad is being refined from time to time to address the changing pest scenario and has proved its sustainability and efficacy beyond doubt. This attempt would be helpful in formulating refined integrated approach to address pest management in *Bt* cotton growing under rainfed ecosystem. The results obtained would be helpful in the demonstration and adoption of this technology on large scale through farmer's participatory approach. With this back ground, a systematic effort was made to develop and evaluate IPM technology for *Bt* cotton hybrids and its performance compared with *Bt* cotton hybrid grown with recommended package of practices (*Bt* RPP).

MATERIALS AND METHODS

An adoptable IPM module was developed both for *Bt* as well as non *Bt* cotton hybrids during 2008-2009 and 2009-2010 at Jeerigiwad village of Dharwad talluk which is situated 20 km away from Dharwad following all recommended agronomic practices. The experiment was carried with 3 modules *viz.*, *Bt* IPM, *Bt* RPP and non *Bt* IPM (Table 1). Each module was laid out on an area of 0.4 ha and separated by a row of maize and cowpea with 1.5 m buffer area distance. Each module was divided into 5 equal blocks to serve as replication for recording observations and statistical analysis. The pest management interventions were carried out as and when the pests crossed ETL. In all the modules, the cotton seeds treated with imidacloprid 70 WS were sown in order to manage the early sucking pests. In IPM module, okra was grown as a trap crop around the blocks in 1:25 and fruits were removed regularly on attaining finger size and sprays were taken to manage sucking pests.

Observations on the incidence of insect

pests were recorded on 25 randomly selected plants in each block at 10 days interval avoiding border rows. Thus, each module served as treatment and block as replication for statistical analysis. The population of mirid bug was recorded after 60 DAS. *Helicoverpa armigera* eggs were recorded starting from 40 DAS and continued up to 70 DAS on central terminal shoot, flower buds, squares and whole plant. The damage to fruiting bodies (squares/ flowers/ bolls) was recorded based on the total number and damaged fruiting bodies in each plant. The fruiting bodies both shed and intact on plants were taken into account for calculating the per cent fruiting body damage. The observations on number of PBW larvae/25 green bolls and per cent green boll damage were recorded in all the blocks. At the time of each picking, the number of good and bad opened bolls and locule damage were recorded from 25 randomly selected plants. The data was averaged / plant and presented as GOBs / BOBs/ plant. Cotton yield was recorded from 5 randomly selected plots of 6 x 5 m^2 from each demarcated replications both in IPM and RPP blocks separately and also from the entire block. Later on the data presented as seed cotton yield / ha for the respective module.

RESULTS AND DISCUSSION

In the present investigation the incidence of sucking pests remained low in both *Bt* IPM as well as non *Bt* IPM modules compared to *Bt* RPP (Table 2). The extent of reduction in aphids, thrips, leafhoppers and mirid bug incidence in *Bt* IPM block was 34.65, 20.10, 12.11 and 6.50 per cent during 2008-2009 and 13.06, 6.17, 5.74 and 4.59 per cent during 2009-2010, respectively, over *Bt* RPP and 12.81, 6.03, 2.29 and 5.74 per cent during 2008-2009 and 10.71, 17.61, 3.41 and 0.91 per cent during 2009-2010, respectively over non *Bt* IPM. Two additional sprays of chemical pesticides with imidacloprid 17.8 SL and acetamiprid 20SP provided protection from the sucking pests. The present findings of sucking pests incidence in IPM modules is in conformity with the result placed on records by Kannan *et al.,* (2004). Seed treatment with imidocloprid followed by the application of systemic insecticides effectively suppressed the

Table 1. Interventions in *Bt* IPM, *Bt* RPP and non *Bt* IPM modules

S.No.	Treatments	Interventions imposed 2008-2009 and 2009-2010
T_1	*Bt* + IPM	1. *Bt* seeds
		2. Okra as trap crop
		3. Installation of pheromone traps
		4. Spraying systemic insecticide for sucking pest control (Acetamiprid 20 SP)
		5. Spraying imidacloprid 200 SL @ 100 ml/ha (310/100 ml)
		6. Spraying of NSKE @ 5 per cent
		7. Spraying of Acephate @ 1 kg/ha
		8. Profenophos 2.01/ha
T_2	*Bt* RPP	1. *Bt* seeds
		2. Spraying systemic insecticide for sucking pest control (Acetamiprid 20 SP) @ 50 g/ha
		3. Spraying of imidacloprid 200 SL @ 100 ml/ha
		4. Spraying of quinalphos 25EC @ 2 l/ha
		5. Spraying of acephate @ 1 kg/ha
		6. Spraying of profenophos 2.01/ha
T_3	Non *Bt* + IPM	1. Non *Bt* seeds
		2. Seed treatment with thiomethoxam @ 5.0 g/kg
		3. Okra as trap crop
		4. Installation of pheromone traps
		5. *Tricho* release @ 2.5 lakh/ ha
		6. Spraying systemic insecticide for sucking pest control (Acetamiprid 20 SP) @ 50 g/ha
		7. Spraying imidacloprid 200 SL @ 100 ml/ha
		8. Spraying of NSKE @ 5 per cent
		9. Spraying of acephate @ 1 kg/ha
		10. Spraying of HaNPV @ 500 LE/ha
		11. Spraying of Profenophos 2.01/ha
		12. Spraying of Chyalothrin 5 EC @ 500 ml/ha
		13. Detopping of cotton shoot tip at 80-90 DAS

Table 2. Population of sucking pests in *Bt* IPM, *Bt* RPP and non *Bt* IPM

Treatments	Aphid/3 leaves			Thrips/3 leaves			Leafhoppers/ 3 leaves			Mirid bug/ 25squares		
	2008-2009	2009-2010	**Mean**	2008-2009	2009-2010	**Mean**	2008-2009	2009-2010	**Mean**	2008-2009	2009-2010	**Mean**
Bt IPM	3.81	7.92	**5.87**	9.50	6.69	**8.10**	3.41	3.12	**3.27**	1.15	8.73	**4.94**
RPP	5.83	9.11	**7.47**	11.89	7.13	**9.51**	3.88	3.31	**3.60**	1.23	9.15	**5.19**
Non *Bt* IPM	4.37	8.87	**6.62**	10.11	8.12	**9.12**	3.49	3.23	**3.36**	1.22	8.81	**5.02**
Reduction over *Bt* RPP (%)	34.65	13.06	**21.42**	20.10	6.17	**14.83**	12.11	5.74	**9.17**	6.50	4.59	**4.82**
Reduction over non *Bt* IPM (%)	12.81	10.71	**11.33**	6.03	17.61	**11.18**	2.29	3.41	**2.68**	5.74	0.91	**1.59**
t value *Bt* IPM *vs* RPP	0.06	0.67	**0.37**	0.61	1.44	**1.03**	0.41	2.06	**1.24**	2.28	5.17	**3.73**
Bt IPM *vs* non *Bt* IPM	1.71	1.30	**1.50**	1.05	1.50	**1.28**	0.11	1.99	**1.05**	0.40	0.14	**0.27**

Table 't' value 2.02

sucking pest complex incidence in both the IPM modules (Patil *et al.,* 2011).

Irrespective of the modules, *Bt* genotypes registered significantly lower population of American bollworm (ABW) owing to the resistance afforded by Cry protein in *Bt* genotypes. Due to trapping of okra, significant reduction in the ABW eggs was observed in both *Bt* and non *Bt* IPM blocks compared to *Bt* RPP (Table 3). The reduction of larval population of ABW was to the tune of 24.14 and 21.05 per cent over *Bt* RPP and 69.44 and 82.35 per cent over non *Bt* IPM during both the seasons. Okra as a component of IPM block trapped the eggs of *Helicoverpa* moth in *Bt* as well as non *Bt* IPM compared to RPP. The extent of reduction of ABW eggs was to the tune of 41.63 and 7.71 per cent over *Bt* RPP. The present findings of use of okra as trap crop in IPM module are in line with the findings of Patil *et al.,* (2011) and Duraimurugan and Regupathy (2005). Similarly, nipping of shoot tip has been proved as effective cultural paradigm for effective management of *H. armigera* egg density (Patil *et al.,* 2011).

Modules with *Bt* genotypes registered significantly less fruiting bodies damages as compared to non *Bt* module. Among the *Bt* and non *Bt* modules, *Bt* IPM block recorded significantly less fruiting body damage (Table 3) indicating the suitability of *Bt* genotypes as an effective components of IPM. Among the module, module with *Bt* IPM recorded significantly less locule damage as compared to *Bt* RPP. Retention of early formed bolls in *Bt* genotypes owing to the inherent *Bt* toxic effect and suppression of bollworm incidence resulted in more good opened bolls in both *Bt* IPM and *Bt* RPP modules.

Modules with *Bt* genotypes registered significantly lower incidence of pink bollworm (PBW) incidence. Both *Bt* IPM as well as *Bt* RPP recorded significantly lower green boll and locule damage as compared to non *Bt* (Table 3). Further the extent of reduction in per cent green boll damage and locule damage was (2.23, 80.93 %) and (2.97, 83.92 %) during 2008-2009 and (2.07, 73.98 %) and (7.09, 76.41 %) over *Bt* RPP and non *Bt* IPM during 2009-2010, respectively. Irrespective of the modules, *Bt* genotypes recorded lower population of PBW compared to IPM with non *Bt* cultivar indicating the effectiveness of *Bt* toxin against PBW. Higher PBW incidence in non *Bt* IPM might be due to lack of target specific treatment for pink bollworm control which resulted in both qualitative and quantitative reduction in seed *kapas*. These results are comparable with the findings of Bambawale *et al.*, (2004), Prasad Rao *et al.*, (2010) Rishi Kumar *et al.,* (2011).

Significantly higher population of natural enemies comprising of coccinellids and *Chrysopa* species was recorded in both the IPM modules. The population of natural enemies remained low in *Bt* RPP which received more number of pesticides application for sucking pest management (Table 5). The present findings are in corroborative with the report s of Patil *et al.,* (2011).

The response of *Bt* genotype as a component of IPM was found to be appreciable in terms of seed cotton yield. Higher seed cotton yield was harvested through *Bt* IPM (25.92 and 25.20q/ha) followed by *Bt* RPP module (23.90 and 24.85q/ha) during both the seasons (Table 6). In both the

Table 3. Bollworms and their damage in *Bt* IPM, *Bt* RPP and Non *Bt* IPM.

Treatments	ABW eggs/plant			ABW larvae/plant			PBW larvae/ 25 green bolls			Fruiting body damage (%)			Green boll damage (%)			Locule damage (%)		
	2008-2009	2009-2010	**Mean**	2008-2009	2009-2010	**Mean**	2008-2009	2009-2010	**Mean**	2008-2009	2009-2010	**Mean**	2008-2009	2009-2010	**Mean**	2008-2009	2009-2010	**Mean**
Bt IPM	3.87	3.83	**3.85**	0.22	0.15	**0.19**	2.50	2.05	**2.28**	3.57	2.73	**3.15**	1.72	2.37	**2.05**	2.29	4.06	**3.18**
RPP	6.63	4.15	**5.39**	0.29	0.19	**0.24**	2.67	2.15	**2.41**	3.75	2.81	**3.28**	1.76	2.42	**2.09**	2.36	4.37	**3.37**
Non *Bt* IPM	3.93	5.05	**4.49**	0.72	0.85	**0.79**	13.31	11.20	**12.26**	6.31	7.12	**6.72**	9.02	9.11	**9.07**	14.24	17.21	**15.73**
Reduction over *Bt* RPP (%)	41.63	7.71	**28.57**	24.14	21.05	**20.83**	6.37	4.65	**5.39**	4.80	2.85	**3.96**	2.27	2.07	**1.91**	2.97	7.09	**5.64**
Reduction over non *Bt* IPM (%)	1.53	24.16	**14.25**	69.44	82.35	**75.95**	81.22	81.70	**81.40**	43.42	61.66	**53.13**	80.93	73.98	**77.40**	83.92	76.41	**79.78**
t value *Bt* IPM *vs* RPP	11.56	4.90	**8.23**	0.29	0.17	**0.23**	0.20	0.42	**0.31**	0.84	0.56	**0.70**	0.05	1.80	**0.93**	0.08	0.70	**0.39**
Bt IPM *vs* non *Bt* IPM	0.24	0.96	**0.60**	5.45	18.92	**12.19**	4.50	2.28	**3.39**	9.55	4.05	**6.80**	3.03	2.12	**4.58**	9.26	2.67	**5.97**

Table 't' value 2.02

Table 4. Natural enemies in *Bt* IPM, *Bt* RPP and non *Bt* IPM

Treatments	Coccinellids/ plant Mean	*Chrysopa*/ plant Mean
Bt IPM	2.61	1.05
RPP	1.31	0.78
Non *Bt* IPM	2.06	0.92
Increase over *Bt* RPP (%)	60.49	48.28
Increase over *Bt* RPP (%)	3.85	11.54
t value *Bt* IPM *vs* RPP	53.94	20.29
Bt IPM *vs* non *Bt* IPM	2462	12.59

Table 't' value 2.02

(*Bt* IPM and *Bt* RPP) modules, cost of plant protection was on lower as compared to non *Bt* IPM.

Table 5. Comparative yield and economics in *Bt* IPM, Bt RPP and non *Bt* IPM

Particulars	*Bt* IPM		*Bt* RPP		Non *Bt* IPM	
	2008-2009	2009-2010	2008-2009	2009-2010	2008-2009	2009-2010
GOB/plant	44.75	35.15	32.25	34.50	28.50	29.72
BOB/plant	1.25	2.13	1.35	2.19	6.70	7.15
Yield (q/ha)	25.9.2	25.20	23.90	24.85	21.40	21.50
Value of yield (Rs/ha)	73,872	88200	68,115	86975	56,710	69875
Protection cost (Rs/ha)	4522	4892	4712	5082	5077	5372
Cost of production (Rs/ha)	8000	9500	8000	9500	8000	9500
Total cost of cultivation (Rs/ha)	12522	14392	12712	14582	13077	14872
Net returns (Rs/ha)	**61350**	**73808**	**55403**	**72393**	**43633**	**55003**

Market rate for *kapas* RCH 2 *Bt*: (2008-2009 Rs.2850/q, RCH 2 Non *Bt*: Rs. 2650/q) (2009-2010 Rs.3500/q, RCH 2 Non *Bt*: Rs. 3250/q)

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