1229 Insect Pest Status and Economics of Bt Cotton Cultivation under Irrigated Ecosystem

Dr. Basavaraj V. Patil , University of Agril. Sciences, College of Agriculture, Raichur - 584 101, India
Mr. Bheemanna M. , University of Agril. Sciences, College of Agriculture, Raichur - 584 101, India
Mr. Shivanand G Hanchinal , University of Agril. Sciences, College of Agriculture, Raichur - 584 101, India

Rationale : Of late cultivation of cotton in irrigated ecosystem has become uneconomical due to increase in protection cost. Transgenic Bt cotton has become an important IPM tool which needs to be evaluated with regard to occurrence of insect pests, natural enemies, monitoring resistance and working out its economic sustainability.

Objectives : Studies on the insect pest status and natural enemies on Bt cotton, Cry 1Ac toxin resistance monitoring for *Helicoverpa* and economics of its cultivation under irrigated eco system.

Methods: Field studies were conducted in both Regional Agricultural Research Station and farmers field for three seasons from 2003-2006. Randomized block design (RBD) with suitable replications were adopted. Standard sampling procedures were followed for population estimation of sucking pests, bollworms and natural enemies. Data was suitably averaged and subjected to suitable transformation and analysed by DMRT method.

Results : Insect pest status on Bt cotton has not changed with regard to sucking pest complex, but there is significant reduction of all the three bollworm population / incidence viz., *Helicoverpa armigera* (Hubner), *Earias vittella* (Fabricius) and *Pectinophora gossypiella* (Saunders) throughout the crop growth, as compared to non Bt cotton hybrid. However, higher incidence of dusky cotton bug. *Oxycarenus laetus* kirby and economic damage of mirid bug, *Crentiodes biseratense* (Distant) was recorded on Bt cotton. Studies also indicated no effect of Bt cotton cultivation on predatory population of cotton insect pests, whereas larval parasitoid population decreased significantly. Monitoring of *Helicoverpa* resistance to Bt cotton from different cotton growing areas indicated no resistance development to Cry 1 Ac toxin. Studies on developing iPM module for Bt cotton indicated integration of components like seed treatment, cultural practices, mechanical collection of grown up larvae, use of biopesticides and selective application of insecticides against sucking pests and bollworms based on ETL.

Conclusion: Commercial cultivation of Bt cotton hybrids in irrigated ecosystem showed significant reduction in pesticide application against bollworms with increased net profit to cotton farmers and has become economically sustainable crop.

Key words: Bt cotton, Non Bt cotton, Sucking pests, Bollworms, Predators, Net profit and IPM.

Introduction

India is one of the largest producer of cotton in the world with the largest area. Bollworms have been the key pest regularly causing decrease in cotton production. Historically pest management has relied largely on synthetic pesticides. This resulted in several

environmental and economic liabilities. Recently development of biotechnological tools facilitated the introduction of genes in to crop plants of economics importance as one of the potential way to combat insect pests and becomes a major tool in Integrated Pest Management (IPM).

Among various transgenic crops, cotton hybrids that express gene derived from the bacterium, *Bacillus thuringiensis* (Bt) has been deployed for combating cotton bolloworms since 2002 in India. Bt cotton cultivation has expanded rapidly to three million hectare of the total cotton area of 8.9 m.ha in 2006-07 (Anonymus, 2006). Initial filed studies showed that Bt cotton yielded more than the non Bt hybrid and was found to be safe for beneficial fauna and reduces the cost of cotton production (Bambawale et al., 2004 and Patil et al., 2005). However, many farmers, consumers and environmentlists adamantly opposed to the transgenic cotton with the intention that Bt cotton causes harmful effects on beneficial organisms, susceptibility to insect pest and non profitable to farmers (Abdul Qayuam and Kiran Sakkhari 2003). This was leading to a state of confusion. Keeping all these points in view present study was undertaken in irrigated ecosystem for three seasons to understand the insect pest status on Bt cotton, effect on natural enemies population, monitoring of *Helicoverpa* registance to Bt cotton, development of IPM schedule and lastly workingout economics of its cultivation.

Materials and Methods

Field studies were conducted in both Regional Agricultural Research Station (RARS) farm and in farmers field of Nelhal village (Tq.&Dt. Raichur, Karnataka, India) which was 15 km away from the research station for three seasons during 2003-04, 2004-05 and 2005-06. Four Bt cotton hybrids viz MECH-162, MECH-184, RCH-2 and NCS-145 were selected for the study along with there non Bt versions. All these were sown in a block of four acres restricting 0.5 acre each for Bt and non Bt hybrid both in research station and also in farmer field.

Observation on sucking pests, bollworms and natural enemies were made on 25 randomly selected and tagged plants in each block. Sucking pests like leafhoppers, aphids, thrips and whiteflies were accorded at weekly interval on three leaves / plant. Emerging new pests like dusky cotton bugs and mirid bugs were recorded on opened bolls and on square basis respectively. Whereas for bollworms infestation, weekly observations on fruiting bodies damage, egg and larval count and rosette flowers (PBW incidence) were recorded. Population of predators viz., spiders, chrysoperla, coccinellids were recorded on whole plant basis. Seed cotton yield of each hybrid in each block was picked separately over three pickings. Data on all above parameters were averaged and analysed for statistical significance with suitable transformation. Net profit and cost benifit ratio was worked out for the average three years data.

IPM protection intervention were made based on the ETL of the insect pest in all the Bt hybrids / blocks at both the locations. Studies on the monitoring of *Helicoverpa armigera* resistance to Bt cotton in different cotton growing areas of Karnataka was carried out by collecting eggs from five different locations. The collected eggs were reared on artificial diet in the laboroatory to neonate larvae and was transferred individually to multicavity trays containing artificial diet coated with Cry 1Ac toxin. Mortality was recorded on 7^{th} day of the treatment. Bioassay was carried out using discriminating dose of 5 µg/mL of diet and log dose probit assay was also worked out for concentrations from 0.01 to 5 µg/mL of diet.

Results and Discussion

There was no difference in the number of interventions made on Bt and non Bt cotton hybrids for sucking pests management in all the three seasons. It required two to three foliar sprays (Table-1) in addition to seed treatment.

Sucking insect pests population in all the Bt and non Bt hybrids was more or less uniform indicating non significant difference (Table-2). MECH-184 Bt and Non Bt required only two sprays as against three sprays in all the other three genotypes because of the genotype tolerance to leaf hoppers. Maximum leaf hoppers and thrips population were recorded during early growth of the crop (50 DAS). Where as aphid population was noticed during later part of the crop growth (90-120 DAS). Whitefly population was below ETL throught the season in all the three years. Bambawale et al., (2004) and Patil et al., (2005) also reported the Bt cotton having no effect on sucking pest population and opined the need for imposition of suitable management strategy. Interestingly the incidence of dusky cotton bug *oxycarenus laetus* Kirby (Patil and Rajanikanth 2005) and mirid bug *Crentiodes biseratense* (Distant) (Patil et al., 2006) were significantly higher (Table-2) in all the Bt cotton hybrids compared to non-Bt cotton hybrids indicating clearly the population buildup which was mainly because of reduction in the number of pesticide application for bollworm management.

Helicoverpa eggs population / growing shoot / plant was also non significant on both Bt and non Bt cotton hybrids indicating no difference in the egg laying habit. Population of *Helicoverpa* larvae / plant varied significantly from 0.04 to 0.72 larvae / plant with negligible population in Bt cotton hybrids and significantly higher population in non Bt cotton hybrids even after regular interventions with pesticide application (Table-3).

Percent fruiting bodies damage due to bollworms was significantly low and on par in all the four Bt cotton hybrids as compared to non Bt cotton hybrids which recorded 8.65 to 12.10 per cent damage even after interventions made based on ETL with pesticide applications. Similarly, percent rosette flowers due to PBW incidence was also significantly low in all the Bt cotton hybrids as compared to non Bt cotton hybrids (Table-3). All the above results clearly indicate the superiority of Bt cotton hybrids in recording lower population / damage due to bollworms. These observations corroborate with earlier reports of Udikeri et al., (2002), Kengegouda (2003) and Patil et al., (2005)

Pooled data on natural enemies indicated that, there was no significant difference among Bt and non Bt hybrid in recording the predatory population viz., spiders, chrysoperla grubs and coccinellid grubs (Table-4). However, percent larval parasitization was significantly low in all the Bt hybrids as compared to larval parasitization in non Bt hybrids which varied from 6.25 to 9.25 per cent. This is mainly because of survival of bollworm larvae in the non Bt cotton hybrids as compared to negligible population survival of bollworm larvae in Bt cotton hybrids. Similar observations were also reported by Hegde, et al (2004).

Monitoring of *H.armigera* population to Cry1Ac toxin during 2005-06 cropping season clearly indicated the LC 50 value ranging from 0.00995 to 0.02384 µg/mL of diet indicating higher level of susceptibility to Bt protein toxin from different cotton growing places of Karnataka state (Table-5). Similarly, Kranti et al (2001) reported that strains from south India periodically showed tolerance levels that ranged from 0.01 to 0.88 µg/mL of diet under laboratory with continuous rearing, whereas field populations recorded higher susceptibility to the Bt cotton protein toxin.

Based on the genetic potentiality of Bt and non Bt hybrids, there was difference with regard to seed cotton yield (Table-6). Highest seed cotton yield of 29.80 q/ha was obtained in RCH-2 Bt followed by NCS-145, MECH-162 and MECH-184 Bt. Where as higher seed cotton yield in non Bt hybrid ranged from 18.25 to 24.50 q/ha with maximum in RCH-2 non Bt. This clearly indicated superiority of Bt cotton hybrids recording higher seed cotton yield. Cost of production of both Bt and non Bt cotton hybrids remain more or less same except for the Bt hybrid seed cost. There was significant difference in the protection cost as non Bt hybrids received more interventions for bollworm management compared to Bt cotton hybrids. Therefore protection cost in non Bt hybrids ranged from Rs. 8350 to 11250 where as it ranged from Rs.2400 to 2800 among Bt cotton hybrids (Table-6).

Net profit in Bt hybrids ranged from Rs. 31900 (MECH-184 Bt) to Rs. 42900 (RCH-2 Bt) where as in non Bt hybrids it ranged from Rs. 14500 (MECH-162 non Bt) to Rs. 25100 (RCH-2 non Bt). Thus, Bt hybrids recorded higher net profit and also higher benefit cost ratio. In general, there was 38.97 to 57.60 percentage increase in net profit over non Bt hybrids among the different genotypes (Table-6). Similar observations were also made in the past by Udikeri et al., (2002), Bambawale et al., (2004) and Patil et al., (2005).

Above studies clearly concludes that cultivation of Bt cotton has not recorded significant change in the sucking insect pest status and natural enemies. Whereas decreased bollworm incidence, no resistance development was observed with increased yield and net profit indicating economic sustainability of the crop under irrigated ecosystem.

Reference:

Abdul. Qayum. & Kiran, Sakkhari. 2003. Did Bt cotton save farmers in Warangal ? A season long impact study of Bt cotton-Kharif 2002 in Warangal district of Andra Pradesh. AP Coalition in Defence of Diversity and the Deccan Development Society, Hyderabad, June, 2003.

Anonymous., 2006, Project Co-ordinator's report, All India Co-ordinated Cotton Improvement Project. CICR Coimbatore.

Bambawale, O.M., Amerika Singh, O.P. Sharma, & B.B. Nhasle, 2004. Performance of Bt cotton (MECH-162) under integrated pest management in farmers participatory field trails in Nanded district, Central India. *Curr. Science*. **86** (12): 1628-1633.

Hegde, M., J. M., Nidagundi, D. P., Biradar, S.S. Udikeri, and B.M., Khadi, 2004, Performance of Bt and non-Bt cotton hybrids against Insect pests under irrigated condition. *In: International symposium on "Strategies for Sustainable Cotton Production – A Global Vision". 3. crop Protection*, 23-25 November 2004, UAS, Dharwad, Karnataka (INDIA), pp. 143-145.

Kengegowda, N. 2003. Studies on the population dynamics and screening of Bt cotton hybrids against insect pests. *M.Sc. (Agri.) Thesis, U.A.S., Dharwad*, India. Pp. 127.

Kranthi, K.R., S. Kranthi and R.R. Wanjori,. 2001. Baseline toxicity of Cry 1Ac toxins to *Helicoverpa armigera*, *International Journal of Pest Management*, **47** : 141-145.

Patil, B.V., M. Bheemanna., A.C. Hosamani., S.G., Hanchinal, N. Kengegowda and R. Rajanikantha. 2005. Bt cotton vis – a – vis conventional hybrid cotton cultivation economics

under irrigated ecosystem. In Advance in Indian Entomology : Productivity and health. Uttar Pradesh Zoological Society (Supplement-3): pp 125-135.

Patil, B.V., M. Bheemanna., S.B. Patil., S.S. Udikeri and A.C. Hosamani, 2006. Record of mirid bug *Crentiodes biseratense* (Distant) on cotton from Karnataka, India. *Insect Environment* : **11** (4) : 176-177.

Patil, B.V. and R. Rajanikanth, 2005. Dusky cotton bug – A future threat for Bt cotton cultivation. *Insect Environment* : **11** (2) : 77-79.

Udikeri, S.S., S.B. Patil., R.N.Hegde., V.N.Kulkarni, & S.S. Patil, 2002. Performance of Bt cotton genotypes under unprotected condition. *National seminar on Bt-cotton Scenario with Special reference to India*. U.A.S., Dharwad Karnataka, 23 May, 2002, pp. 90.

Table-1: Protection interventions made in Bt and non Bt cotton hybrids

Interventions	Bt cotton hybrids *				Non Bt cotton hybrids *			
	MECH-162	MECH-184	RCH-2	NCS-145	MECH-162	MECH-184	RCH-2	NCS-145
1) Sucking pests management								
a) Seed treatment with imidacloprid 70 WS at sowing	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
b) Foliar insecticide sprays	3	2	3	3	3	2	3	2
2) Bollworm management:								
a) Trap crop (pigeonpea border row)	-	-	-	-	Yes	Yes	Yes	Yes
b) Release of *Trichogramma* egg parasitoids	-	-	-	-	2	2	2	2
c) Ha NPV spray	-	-	-	-	1	1	1	1
d) Mechanical collection of grown up larvae	1	1	1	1	2	1	2	2
e) Insecticide sprays	1	1	1	1	6	4	7	7
3) Total Interventions	6	5	6	6	16	12	17	16

*** Interventions were made based on ETL of pest population / damage**

Table-2: Population of sucking pests in Bt and non Bt cotton hybrids (pooled data of three seasons)

Insect pest	Mean number of sucking pests							
	Bt cotton hybrids				Non Bt cotton hybrids			
	MECH-162	MECH-184	RCH-2	NCS-145	MECH-162	MECH-184	RCH-2	NCS-145
Thrips/leaf	3.85[a]	2.90 [a]	4.10 [a]	3.78 [a]	3.90 [a]	3.12 [a]	4.15 [a]	3.88 [a]
Leaf hoppers/leaf	0.88 [a]	0.93 [a]	1.02 [a]	0.95 [a]	0.80 [a]	0.90 [a]	1.10 [a]	1.05 [a]
Aphids/leaf	11.30 [a]	8.90 [a]	12.10 [a]	11.95 [a]	9.90 [a]	8.35 [a]	12.35 [a]	12.05 [a]
Whiteflies/leaf	1.10 [a]	1.25 [a]	1.42 [a]	1.35 [a]	1.02 [a]	1.40 [a]	1.55 [a]	1.45 [a]
Dusky cotton bugs/boll	9.35 [b]	10.15 [b]	9.10 [b]	9.92 [b]	3.10 [a]	2.68 [a]	2.90 [a]	3.12 [a]
Mirid bugs/square	2.85 [b]	2.05 [b]	2.90 [b]	2.80 [b]	0.25 [a]	0.19 [a]	0.35 [a]	6.32 [a]

Letter denoted by same letters on the horizontal axis are not significant at p=0.05 level by DMRT

Table-3: Population / damage of bollworms in Bt and non Bt cotton hybrids (pooled data of three seasons)

Parameters	Bt cotton hybrids				Non Bt cotton hybrids			
	MECH-162	MECH-184	RCH-2	NCS-145	MECH-162	MECH-184	RCH-2	NCS-145
1. *Helicoverpa* eggs / growing shoot / plant	1.95 [a]	2.05 [a]	2.10 [a]	2.15 [a]	2.10 [a]	1.88 [a]	2.07 [a]	2.18 [a]
2. *Helicoverpa* larvae / plant	0.08 [a]	0.04 [a]	0.10 [a]	0.08 [a]	0.58 [c]	0.32 [b]	0.65 [b]	0.72 [c]
3. Percent fruiting bodies damage due to bollworms	2.10 [a] (8.33)	1.85 [a] (7.72)	2.20 [a] (8.53)	2.30 [a] (8.70)	11.25 [c] (19.58)	8.65 [b] (17.10)	12.10 [b] (20.35)	11.30 [c] (19.65)
4. Percent rosette flowers due to PBW	0.85 [a] (5.28)	1.10 [a] (6.05)	1.25 [a] (6.30)	0.90 [a] (5.40)	12.85 [e] (20.98)	9.10 [b] (17.55)	13.55 [b] (21.58	15.10 [c] (22.88)

Letter denoted by same letter on the horizontal axis are not significant at P=0-05 level by DMRT

Figures in the parenthesis are angular transformed arc sign values for analysis.

Table-4: Population of Natural enemies on Bt and non Bt cotton hybrids (pooled data of three seasons)

Natural enemies	Mean number of predators per plant							
	Bt cotton hybrids				Non Bt cotton hybrids			
	MECH-162	MECH-184	RCH-2	NCS-145	MECH-162	MECH-184	RCH-2	NCS-145
Predators								
1. Spiders	2.18 [a]	1.95 [a]	2.30 [a]	2.25 [a]	2.05 [a]	2.00 [a]	2.20 [a]	2.05 [a]
2. Chrysoperla grubs	1.40 [a]	1.65 [a]	1.50 [a]	1.48 [a]	1.25 [a]	1.18 [a]	1.22 [a]	1.25 [a]
3. Coccinellid grubs	5.35 [a]	3.85 [a]	4.70 [a]	5.12 [a]	4.85 [a]	4.05 [a]	4.92 [a]	3.95 [a]
4. Percent larval parasitization	0.60 [b] (4.45)	0.50 [b] (4.05)	0.35 [b] (3.50)	0.45 [b] (3.85)	9.25 [a] (17.65)	6.25 [a] (14.40)	7.30 [a] (15.68)	8.25 [a] (16.65)

Letter denoted by same letter on the horizontal axis are not significant at P=0-05 level by DMRT

Figures in the parenthesis are angular transformed arc sign values for analysis.

Table-5: Suceptibility of *Helicoverpa armigera* (Hb) population to Bt Cry 1 Ac toxin collected from different locations of Karnataka during 2005-06 season

Sl.No.	District place of collection in Karnataka, India	Agro Ecosystem	LC 50 µg/mL	FL 95%
1	Bellary	Irrigated	0.02220	0.0158-0.0294
2	Gulbarga	Irrigated	0.01970	0.0149-0.0249
3	Raichur	Irrigated	0.02248	0.01516-0.0303
4	Dharwad	Rainfed	0.02384	0.0173-0.0312
5	Haveri	Rainfed	0.00995	0.0063-0.0142

n=500 larvae

Table-6: Economics of Bt and non Bt cotton cultivation in irrigated ecosystem

Cotton hybrids	Seed cotton yield (q/ha)	Total income (Rs/ha)	Cost of cultivation (Rs/ha)		Total cost (Rs/ha)	Net profit (Rs/ha)	B:C ratio	Percent net profit increase over non Bt
			Production cost	Protection cost				
Bt cotton hybrid								
1. MECH-162	25.25	50500	13500	2800	16300	34200	3.10	57.60
2. MECH-184	23.90	47800	13500	2400	15900	31900	3.00	50.15
3. RCH-2	29.80	59600	13900	2800	16700	42900	3.57	41.50
4. NCS-145	28.75	57500	13900	2800	16700	40800	3.44	38.97
Non Bt cotton hybrid								
1. MECH-162	18.60	37200	12250	10450	22700	14500	1.64	--
2. MECH-184	18.25	36500	12250	8350	20600	15900	1.77	--
3. RCH-2	24.50	49000	12650	11250	23900	25100	2.05	--
4. NCS-145	24.20	48400	12650	10850	23500	24900	2.06	--

Average price of cotton : Rs. 2000 per quintal