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Biointensive Integrated Pest Management for Bt Cotton

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Abstract: Biointensive Integrated Pest Management (BIPM) modules were compared with the Farmers' Package of Practices (FPP) for MECH 162 Bt and MECH 162 N Bt The incidence of leaf hopper, aphids, thrips and whiteflies in different modules was in the order of FPP-MECH 162 Bt > BIPM MECH 162 Bt > BIPM MECH 162 N Bt > FPP MECH 162 N Bt. Natural enemies population were more in BIPM modules than the FPP. Coccinellids such as *Menochilus sexmaculatus*, *Coccinella transversalis* and spiders *Oxyopes* spp., *Argiope* spp., *Neoscona* spp., *Araenus* spp. and *Plexippus* spp. were frequently observed in the field trials. Incidence of bollworm population was more in winter field trial than that in the summer field trials. Fruiting bodies damage, open boll, locule and inter locule damage in different modules was in the order of BIPM MECH 162 Bt > FPP MECH 162 Bt > BIPM MECH 162 N Bt > FPP MECH 162 N Bt. Seed cotton yield in BIPM MECH 162 Bt, BIPM MECH 162 N Bt, FPP MECH 162 Bt and FPP MECH 162 N Bt modules at Alandurai field trial were 1920, 1640, 1800 and 1440 kg ha^{-1}. The results indicated the better performance of Bt cotton in both the modules. BIPM approach reduces the insecticide usage. The IPM approach is essential for gaining higher advantage from Bt cotton as it takes care of varying pest situation.

Key words: BIPM, Inter locule damage, Insecticide, Bt cotton

Introduction

Indian cotton production is third in the world in quantity, although the productivity is very low compared to world average of 582 kg ha^{-1} (Sharma, 2001). As there is little possibility of increase in area under cotton, the productivity has to be increased to meet our local demand (Puri *et al*., 1999).

Among the several factors contributing to low productivity, biotic constraints appear to be very important. Cotton plant is infested by 162 species of insects at various stages of growth, of which 15 are considered to be key pests. Among these, the boll worms and sucking pests are important. The average loss in yield of seed cotton due to insect pests ranges 50-60% (Dhaliwal *et al*., 2004). The minimum losses were caused by sucking pests (4.6%) whereas bollworms (51.3%) cause maximum loss (Satpute *et al*., 1985). Among these *H. armigera* causes US $ 290-350 million worth of damage every year in India (Gujar *et al*., 2000).

Nearly 12 billion worth of pesticides are used in India to control the bollworm complex of cotton (Barwale *et al*., 2004). Increased reliance on pesticides over the years have replaced traditional control methods and indiscriminate use of conventional insecticides as well as synthetic pyrethroids has created resistance among some of the key pests, including the cotton bollworm, *H. armigera* (Sharma *et al*., 2000).

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Though cultural practices, resistance traits (Sadras, 1995) and beneficial fauna activity (Wilson *et al*., 1994) make it possible to reduce the insect pest damage, the economic sustainability of the cotton crop is not realized. Biocontrol agents including several biopesticides have not been included in the schedule of the bollworm complex management (Khadi *et al*., 2001).

Transgenic cotton, engineered to continuously express δ-endotoxin from the Bt gene, holds great promise for controlling bollworm complex (Gould, 1988). Host plant resistance provides sound platform for pest management and therefore has been considered as important component in any IPM modules. For sustainable use of transgenic cultivars and maintenance of natural control systems biointensive integrated pest management (BIPM) packages are essential. The transgenic cotton expressing endotoxin protein of Bt could reduce the impact of chemical insecticides and create ecologically sound breeding programmes without reducing crop production as a part of an IPM strategy (Lutterell and Herzog, 1994). In the present study Biointensive Integrated Pest Management (BIPM) modules were evaluated to manage the sucking pest and bollworm complex to Bt cotton.

Materials and Methods

The present experiments were conducted in farmers field at Alandurai and Thondamuthur during summer 2004, and winter 2004-05, respectively. The cultivar MECH 162 Bt and MECH 162 N Bt were sown with a spacing of 90×90 cm. The seeds were provided by Project Directorate of Biological control (PDBC), Bangalore. Each treatment was laid out in an area of 0.2 ha with four replications. The agronomic practices and application of FYM at the rate of 25 t ha^{-1} was uniform for all treatments which was Tamil Nadu Agriculture University, Coimbatore, recommendations to maintain ideal crop stand (Anonymous, 1999). The different combinations of treatments are as follows:

Bt Cotton MECH 162 with BIPM Package

1. Seed treatment with *Trichoderma harzianum* (5 g kg^{-1} seed)
2. Border crop of maize (Co_2)
3. Release of three days old grubs of *Chrysoperla carnea* at the rate of 14,000 ha^{-1} once at initial aphid build up stage
4. Spray of SlNPV at the rate of $3x10^{12}$ POBs ha^{-1}, if *Spodoptera litura* is seen (SlNPV mixed with 0.5% crude sugar as UV protectant and surfactant, when larvae are in 1st to 3rd instar stage)
5. Non Bt cotton as refugia as recommended

Non Bt Cotton MECH 162 with BIPM Package

1. Seed treatment with *Trichoderma harzianum* (5 g kg^{-1} seed)
2. Border crop of maize (Co_2)
3. Release of three day old grubs of *C. carnea* at the rate of 14,000 ha^{-1} once at initial aphid build up stage
4. Release of *Trichogramma chilonis* at the rate of 1,50,000 ha^{-1} $week^{-1}$ synchronising with the appearance of bollworm (6-8 releases as per incidence)
5. Application of Bt at the rate of 1 kg ha^{-1} when any of the bollworm is seen. If *H. armigera* is seen HaNPV at the rate of $3x10^{12}$ POBs ha^{-1} applied.
6. Spray of SlNPV at the rate of $3x10^{12}$ POB ha^{-1}, if *S. litura* is noticed.

Bt Cotton MECH 162 with Existing Farmers Practices

1. Seed treatment with Gaucho at the rate of 10 g kg^{-1} seed
2. Sucking pest management
   a. Acephate 75 SP at the rate of 750 g ha^{-1} spray (45 DAS)
3. Bollworm management
   a. Spraying of monocrotophos 36 WSC at the rate of 2000 mL ha^{-1} (60 DAS)
   b. Spraying of endosulfan 35 EC at the rate of 2000 mL ha^{-1} (70 and 80 DAS)
   c. Spraying of chlorpyriphos 20 EC at the rate of 2000 mL ha^{-1} (100 DAS)
4. Non Bt cotton as refugia as recommended.

Non Bt Cotton MECH 162 with Existing Farmers Practice

1. Seed treatment with Gaucho at the rate of 10 g kg^{-1} seed
2. Insecticide schedule as per the earlier section.

The number of bollworms (*H. armigera* and *E. vittella*) were counted at 10 locations by selecting randomly five plants in each location (200 m^2/loction) at 15 days interval starting from 15 DAS. The percent damage to fruiting bodies was recorded at 10 locations by selecting randomly five plants in each location at 15 days interval. The locule and inter locule damage were recorded at the time of harvest. In case of pink bollworm larval counts per ten bolls were taken. The observations were continued up to 150 DAS. The observations on sucking pests and natural enemies were recorded from 15 DAS onwards and continued up to 120 DAS. The data were analysed as described by Gomez and Gomez (1984).

Results and Discussion

The major reason for the interest on Bt cotton in India is attributed to the skewed quantum of insecticide used on the cotton, particularly against *H. armigera* which is considered as the national pest which can lead to potential of 60-80% yield loss and its developed resistance to almost all group of insecticides. Transgenic crops are the important component of integrated pest management (Yuan *et al*., 1999). The performance of MECH 162 Bt and non Bt hybrids in the BIPM and FPP modules were investigated.

The incidence of sucking pests in different modules was in the decreasing order of FPP MECH 162 Bt > BIPM MECH 162 Bt > BIPM MECH 162 N Bt > FPP MECH 162 N Bt (Table 1). The

Table 1: Incidence of sucking pest population in different modules at different locations

	Mean number of insects over the season*			
Modules	Leafhopper	Aphids	Thrips	Whiteflies
Alandurai (Summer 2004)				
BIPM-MECH 162 Bt	4.10 (2.26)^b	3.20 (2.04)^b	1.34 (1.52)^b	1.40 (1.54)^b
BIPM-MECH 162 N Bt	4.30 (2.30)^c	3.46 (2.11)^c	1.54 (1.59)^c	1.54 (1.59)^c
FPP-MECH 162 Bt	3.04 (2.01)^a	2.58 (1.89)^a	1.14 (1.46)^a	1.26 (1.50)^a
FPP-MECH 162 N Bt	7.08 (2.85)^d	6.42 (2.72)^d	2.52 (1.87)^d	2.44 (1.85)^d
Thondamuthur (Winter 2004-2005)				
BIPM-MECH 162 Bt	3.12 (2.02)^b	2.92 (1.97)^b	1.44 (1.56)^b	1.46 (1.56)^b
BIPM-MECH 162 N Bt	3.30 (2.07)^c	3.02 (2.00)^c	1.54 (1.59)^c	1.54 (1.59)^a
FPP-MECH 162 Bt	2.54 (1.88)^a	2.18 (1.78)^a	1.08 (1.44)^a	1.04 (1.42)^c
FPP-MECH 162 N Bt	5.36 (2.52)^d	5.62 (2.57)^d	2.46 (1.86)^d	2.50 (1.87)^d

*Mean of ten observations, *Figures in parenthesis are $\sqrt{x+1}$ transformed values, Means followed by different letter within column indicate significant differences (p = 0.05 DMRT) seed treatment with imidacloprid in FPP MECH 162 Bt reduced the sucking pest population, to a lower level than the other methods. The release of *C. carnea* at 45 DAS kept the sucking pest population incidence to a moderate level in BIPM modules.

Bhosle *et al.*(2004) studied the incidence of sucking pests in MECH 162, MECH 184, MECH 12 Bt and non Bt hybrids and they concluded that MECH 162 Bt and non Bt tolerant to sucking pest complex than the other hybrids. The release of *C. carnea* effectively reduced the sucking pests (Kulkarni *et al.*, 2004) and bollworms (Anonymous *et al.*, 1990). Hegde (1987) released *C. carnea* by larval brushing method and it reduced the insecticide application for sucking pests, bollworms and recorded higher yield of cotton.

The seed treatment with imidacloprid reduced the sucking pest population below economic threshold level up to 40 DAS (Mote *et al.*, 1995; Patil *et al.*, 2004 and Kannan *et al.*, 2004) and was effective against leafhopper population up to 60 DAS (Dandale *et al.*, 2001).

The incidence of natural enemies were more in BIPM modules than the FPP module plots (Table 3). Kulkarni *et al.* (2004) also recorded similar kind of results. Maximum activity of coccinellids and *C. carnea* was recorded in MECH 162 Bt BIPM and MECH 162 NBt BIPM modules. The decreased abundance of sucking pest population in FPP-MECH 162 Bt and the use of systemic insecticides in FPP MECH 162 N Bt might have reduced the incidence of their natural enemies. Kannan *et al.* (2004) and Satpute *et al.* (2002) concluded that the imidacloprid seed treatment attracted the coccinellids and lacewings. The lower incidence of sucking pest populations in the FPP MECH 162 Bt module, might have favoured the movement of these insects towards BIPM modules in this study.

Yuan *et al.* (1999) stated that the bollworm resistance in Bt cotton brings down the usage of insecticides by 60-80% and natural enemies population increases. In the present study, lower incidence of bollworm damage was noticed in MECH 162 Bt in both the modules than their isogenic lines. Similar trends were also noticed by several workers Yuan *et al.* (1999), Wu *et al.* (1999), Hegde (1987); Bhosle *et al.* (2004) and Kulkarni *et al.* (2004). Hedge *et al.* (2004) revealed that among the hybrids MECH 162 Bt (15.67) recorded lower boll damage than MECH 184 Bt (19.12) and MECH 12 Bt.

Bhosle *et al.* (2004) reported that the population of spotted bollworm (*E. vittella*) was significantly low in Bt cotton hybrids as compared to non Bt hybrids. They also recorded less population of *H. armigera* was noticed on MECH 162 Bt and MECH 184 Bt (0.87 larva/plant). Similarly in the present study, all the three locations the incidence spotted and american bollworms were very low in the Bt cotton hybrid (MECH 162) than the non Bt hybrid

The locule and intelocule damage was lower in Bt cotton MECH 162 than the non Bt in both the modules. The order of locule and interlocule damage was BIPM MECH 162 Bt > FPP MECH 162 Bt > BIPM MECH 162 N Bt > FPP MECH 162 N Bt. Similar observation also made by several researchers (Bhosle *et al.*, 2004; Kulkarni *et al.*, 2004; Hedge *et al.*, 2004)

The pink bollworm *P. gossypiella* population was significantly low, (0 to 0.5) in the Bt cotton hybrids viz., RCH 2, RCH 20, RCH 144 and MECH 162 while it was 1.5 to 2.2 and 1.3 in the non Bt counterparts and check (Surulivelu *et al.*, 2004). Hennebery and Jah (2000) reported that Bt cotton bolls (NuCOTN 33^B and DPL 5415) developing on plants 180 Days after Planting (DAP) were also toxic to pink bollworm larvae.

In the BIPM module, as the incidence of *H. armigera* was below Economic Threshold Level (ETL) throughout the crop period, HaNPV was not applied in the BIPM modules. The effectiveness of HaNPV to manage *H. armigera* in cotton ecosystem was already proved by Dhandapani *et al.* (1987), Sathiah (2001), Mastdi *et al.* (1995).

Table 2: Incidence of bollworm damage in different modules

Modules	Mean larval population/Plant *			Bollworm damage$^{\$}$ (%)			
	H. armigera	*E. vittella*	Fruiting bodies	Open boll	Locule	Inter locule	Yield (kgha^{-1})
Alandurai (Summer 2004)							
BIPM-MECH 162 Bt	0.13 (1.06)^{a}	0.25 (1.11)^{a}	0.33 (3.29)^{a}	0.55 (4.25)^{a}	0.20 (2.55)^{a}	0.30 (3.13)^{a}	1920^{a}
BIPM-MECH 162 N Bt	0.30 (1.14)^{b}	0.37 (1.17)^{c}	0.82 (5.20)^{c}	1.05 (5.86)^{c}	0.70 (4.77)^{c}	0.85 (5.27)^{c}	1640^{c}
FPP-MECH 162 Bt	0.14 (1.06)^{a}	0.27 (1.13)^{b}	0.40 (3.62)^{b}	0.65 (4.62)^{b}	0.25 (2.85)^{b}	0.32 (3.27)^{b}	1800^{b}
FPP-MECH 162 N Bt	0.47 (1.22)^{c}	0.57 (1.26)^{d}	1.80 (7.70)^{d}	2.05 (8.23)^{d}	1.40 (6.79)^{d}	1.45 (6.91)^{d}	1440^{d}
Thondamuthur (Winter 2004-05)							
BIPM-MECH 162 Bt	0.40 (1.18)^{a}	0.09 (1.04)^{a}	1.30 (6.54)^{a}	1.95 (8.02)^{a}	0.90 (5.44)^{a}	1.05 (5.89)^{a}	2040^{d}
BIPM-MECH 162 N Bt	0.91 (1.38)^{c}	0.19 (1.08)^{c}	2.45 (9.00)^{c}	3.50 (10.78)^{c}	1.85 (7.81)^{c}	2.25 (8.62)^{c}	1680^{d}
FPP-MECH 162 Bt	0.47 (1.27)^{b}	0.10 (1.05)^{b}	1.80 (7.70)^{b}	2.50(9.09)^{b}	1.40 (6.79)^{b}	1.50 (7.03)^{b}	1740^{d}
FPP-MECH 162 N Bt	1.40 (1.54)^{d}	0.71 (1.30)^{d}	6.02 (14.21)^{d}	7.30 (15.67)^{d}	3.40 (10.62)^{d}	4.10 (11.68)^{d}	1480^{d}

Table 3: Incidence of natural enemies in different modules

Alandurai (Summer 2004)

Modules	Mean number of insects over the season *	
	Green lacewing	Coccinellids
BIPM MECH 162 Bt	0.33 (1.15)^{a}	1.44 (1.56)^{a}
BIPM MECH 162 N Bt	0.32 (1.14)^{b}	1.06 (1.43)^{b}
FPP MECH 162 Bt	0.28 (1.10)^{c}	0.94 (1.39)^{c}
FPP MECH 162 N Bt	0.11 (1.05)^{d}	0.74 (1.31)^{d}

Thondamuthur (Summer 2004-05)

Modules	Mean number of insects over the season *	
	Green lacewing	Coccinellids
BIPM MECH 162 Bt	0.45 (1.20)^{a}	1.84 (1.68)^{a}
BIPM MECH 162 N Bt	0.41 (1.18)^{b}	1.38 (1.54)^{b}
FPP MECH 162 Bt	0.28 (1.10)^{c}	1.34 (1.52)^{c}
FPP MECH 162 N Bt	0.32 (1.15)^{d}	1.20 (1.48)^{d}

*Mean of ten observations, *Figures in parenthesis are $\sqrt{x+1}$ transformed values, Means followed by different letter within column indicate significant differences ($p = 0.05$ DMRT)

Significant differences were noticed for yield of seed cotton among Bt and non Bt cotton (Elena, 2001). All the three seasons MECH 162 Bt in both modules recorded more seed cotton yield than the non Bt hybrids . The seed cotton yield in different modules was in the order of BIPM MECH 162 Bt > FPP MECH 162 Bt > BIPM MECH 162 N Bt > FPP MECH 162 N Bt (Table 2).

Kulkarni *et al.* (2004) revealed that Bt cotton MECH 162 in both BIPM and RPP recorded higher yield (11.00 and 13.00 g ha^{-1}) compared to non Bt (8.50 and 12.25 q ha^{-1}). Similar results recorded by Bambawale *et al.* (2004); Vennila *et al.* (2004); Hedge *et al.* (2004); Bhosle *et al.* (2004).

The compatibility of Bt cotton with the Integrated Pest Management (IPM) approaches was already recorded by Yuan *et al.* (1999). The results clearly indicated better performance of Bt cotton (MECH 162) in both the modules. BIPM approach reduces the insecticide usage. The IPM approach is essential for gaining higher advantage from Bt cotton as it takes care of varying pest situation. Even though, FPP proved better in reducing pests of cotton, it is advisable to opt for biorational approaches to manage pests of cotton for prolonged efficacy and better use of transgenic cultivars owing to their eco friendly nature.

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