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INSECT PESTS MANAGEMENT OF BT COTTON THROUGH THE MANIPULATION OF DIFFERENT ECO-FRIENDLY TECHNIQUES

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This study was designed to manage insect pests of Bt cotton through the manipulation of different eco-friendly techniques. A perusal of data, based on the overall performance of different treatments reflected that lowest population of jassids (0.29) was observed in bio-control treated Bt cotton followed by bio-control treated conventional cotton (0.41). Mean per leaf population of thrips was found lowest in insecticide treated Bt cotton (0.97) which was statically at par with bi-control treated conventional cotton (0.95), biocontrol treated Bt cotton (1.09) and colour traps treated Bt cotton (1.50). In case of whiteflies, bio-control treated Bt cotton and bio-control treated conventional cotton again proved effective in maintaining the population at lower levels per leaf (0.33 and 0.35 respectively). No bollworms infestation was recorded in transgenic cotton whereas higher attack of the same was observed in the untreated conventional cotton block. The best results were achieved with the application of bio-control agents in combination with Bt cotton resulting in least infestation by insect pests and maximum seed yield of 3657 kg/ha. The population of *Chrysoperla carnea* was significantly higher in Bt and conventional cotton treated with bio-control agents as compared to the other treatments. The parasitism percentage of *Trichogramma chilonis* was observed significantly higher in bio-control treated conventional cotton. The studies manifested that combination of bio-control technology with Bt cotton effectively preserves the local beneficial insect fauna indicating its potential to be used as integrated management system against different insect pests of cotton.

Keywords: Bt cotton, Sucking pests, Chrysoperla carnea, Trichogramma chilonis

1. Introduction

Cotton (*Gossypium hirsutum* L.), is the major cash crop of Pakistan known as “white gold”. It is a significant source of foreign exchange earning in the country. Pakistan is the fourth largest producer of cotton in the world, the third largest exporter of raw cotton and the fifth largest consumer of cotton. In Pakistan, it is grown on an area of about 3031.5 thousand hectares having cotton lint production of 12452.5 thousand bales with average yield of 699 kg / ha [1]. This per hectare yield is very low as compared to other major cotton producing countries. There are many reasons responsible for the low yield of cotton but insect pest infestation is one of the major reasons [2].

The insect pests spectrum of cotton is quite complex and as many as 1326 species of insect pests have been reported to attack this crop throughout the world. However, main losses in cotton yield are due to its susceptibility to about 162 species of insect pests [3]. Among these, the bollworms *viz*., American bollworm *Helicoverpa armigera* (Hubner), spotted bollworm *Earias vittella* (Fabricius), spiny bollworm *Erias insulana* (Biosdual) and pink bollworm *Pectinophora gossypiella* (Saunders) pose greater threat to cotton production. Besides these, a complex of sucking pests *viz*., green leaf hopper, *Amarasca biguttula* (Ishida), thrips, *Thrips tabaci* (Lindeman), aphids, *Aphis gossypii* (Glover), whitefly, *Bemisia tabaci* (Gennadius), red cotton bug, *Dysdercus koenigii* (Fabricius) and dusky cotton bug, *Oxycaranus hayalinipennis* (Costa) occupy major pest status and contribute to lower yields [4].

In cotton fields, broad-spectrum insecticides are generally applied for the control of different sucking and chewing insect pests. The introduction of Bt varieties has already dramatically reduced the amount of chemical pesticides applied to cotton [5]. The use of transgenically modified cotton that expresses an insecticidal protein derived from *Bacillus thuringiensis* Berliner (Bt) is revolutionizing

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global agriculture [6]. The principal advantage of using GM plants to manage insect pests is clearly the potential for reduced broad-spectrum insecticides. Around the globe, use of Bt cotton has consistently resulted in a 60-80% decrease in insecticide applications in this crop. The aim of integrated pest management (IPM) is to become less reliant upon synthetic insecticides, especially as a prophylactic measure [7].

The area under Bt cotton in Pakistan increased spectacularly in 2005, when Pakistan Atomic Energy Commission (PAEC) provided 40,000 kg seed of the Bt cotton strains namely IR-FH-901, IR-NIBGE-2, IR-CIM-448 and IR-CIM-443, which were grown on over 3,238 ha (hectares) during the 2005-2006 cotton season [8, 9]. There are numerous arthropods in cotton fields, while the Bt protein is toxic to only narrow spectrum of lepidopteran species. The dynamics of other species may be indirectly affected. Effects on non-target species may be positive due to the exclusion of disruptive insecticides, or negative due to the effective removal of prey [10]. Potential route of parasitoids and predator's exposure to Bt proteins include direct feeding on pollen, nectar or other plant tissues, or secondary exposure through feeding on prey species that have themselves fed upon Bt plants. Bt protein expression in crops is highest in actively growing green tissues, lower in older vegetative tissues and reproductive tissues, and lowest or absent in the phloem [11, 12].

Keeping in view the sucking pests menace to Bt cotton and potential risk of transgenic cotton to bio-control agents, a particular source of concern, an experiment was designed to manage insect pests of Bt cotton through different environment friendly techniques and to find out impacts of Bt cotton on non target insect species especially insect predators and parasitoids.

2. Materials and Methods

To study the compatibility of Bt cotton with beneficial insects, Bt cotton (IR-1524) and conventional cotton (NIA-Ufaq) were grown at the experimental farm of Nuclear Institute of Agriculture (NIA), Tandojam during April 2010. There were six treatments (Bt + biocontrol, Bt + colour traps, Bt + insecticide, Bt cotton alone, conventional + biocontrol and conventional cotton alone) replicated three times. The seed rate used was 20 kg per ha with row to row and plant to plant distance of 0.75 and 0.25 m, respectively. The experimental area was divided into 18 plots each plot with 5m×8m area. Biocontrol treated plots were kept completely separated and at a considerable distance from other plots. A distance of about 1.0 m between the treatments and 1.5 m between replications was maintained among other plots. Bio-control agents, *Chrysoperla carnea* (Stephens) and *Trichogramma chilonis* (Ishii) were reared under laboratory condition (25 $\pm$ 2^{o}C and 65-70% RH) on the eggs of *Sitotroga cerealella* (Olivier). Yellow and blue sticky colour traps for sucking complex were obtained from the Plant Protection Division of Nuclear Institute of Agriculture Tandojam. Insecticide (confidor) was purchased from local market and applied @ 250 ml / acre. The surveillance of cotton crop was initiated at the emergence of seedlings and continued up to the month of October. All agronomic practices followed were uniform in whole cotton field under trial and recommended doses of fertilizers were applied. The bio-control agents were released regularly at fortnightly interval @ 10 cards of *C. carnea* eggs and 5 cards of *T. chilonis* / acre (*C. carnea* 100 eggs / card and *T. chilonis* 2000 / card).

The data was collected regularly at weekly interval throughout the cotton crop. The plant inspection method was used for sampling and the populations of three major sucking pests jassids, thrips and whiteflies were recorded early in the morning at weekly interval by observing the three leaves (One each from top, middle and bottom) from randomly selected three plants and transformed on per leaf basis. Infestation of bollworms was recorded by observing the buds, flowers and dissecting the bolls on randomly selected three plants from each replication. Percent infestation of pink bollworm and spotted bollworm was calculated separately by recording total number of fruiting parts (Buds, flowers and bolls) and numbers of damaged fruiting parts from three plants in each replication using formula:

$$\text{Percent infestation} = \frac{\text{No. of damaged fruiting}}{\text{Total No. of fruiting parts}} \times 100$$

In case of *C. carnea*, its different stages i.e. eggs, larvae, pupae and adult were recorded per 5 plants in each replication. While the population of *T. chilonis* was recorded as percent (%) parasitism after exposure of fresh egg cards of Angoumois grain moths for 24 hours in the field.

$$\text{Percent parasitism} = \frac{\text{No. of eggs parasitized}}{\text{Total No. of eggs offered}} \times 100$$

The data recorded were analyzed by using computer software Statistix.

3. Results and Discussion

3.1. Ecofriendly Management of Insect Pests of Bt Cotton

Results indicated that infestation of sucking pests varied greatly in different treatments (Table 1). Mean per leaf population of jassids fluctuated to a great extent in different treatments. Lowest population of jassids (0.29) was observed in biocontrol treated Bt cotton followed by biocontrol treated conventional cotton (0.41). Insecticide treated Bt cotton (0.53) also successfully suppressed jassid pest attack which was found at par with biocontrol treated conventional cotton and colour traps treated Bt cotton. Highest population of jassids per leaf was recorded in untreated conventional cotton (0.97) followed by untreated Bt cotton (0.93) which was obviously because of absence of different control strategies in these plots. Mean per leaf population of thrips was found lowest in insecticide treated Bt cotton (0.97) however it was non significantly different with biocontrol treated conventional cotton (0.95), biocontrol treated Bt cotton (1.09) and colour traps treated Bt cotton (1.50). The decreased population densities of this pest in sprayed plots were mainly due to the impact of pesticide used against sucking pests. Population of thrips with no significant difference was observed between untreated Bt cotton (2.79) and untreated conventional cotton (2.63) that was significantly higher from the rest of treatments. Lowest per leaf infestation of whiteflies was observed in biocontrol treated Bt cotton (0.33) followed by biocontrol treated conventional cotton (0.35) however, whiteflies population in insecticide treated Bt cotton (0.40) and colour traps treated Bt cotton (0.47) was found at par with conventional cotton plots treated with natural enemies. Maximum infestation was observed in untreated conventional cotton (0.82) followed by untreated transgenic cotton (0.78).

Bt toxins are known to have a very specific mode of action against almost all lepidoteran pests which efficiently manage pest populations in an economically viable and environmentally safe manner that is why no bollworms infestation was recorded in transgenic cotton plots. On the other hand the non Bt cotton are quite susceptible to the attack of these bollworms which is one of the major reasons responsible for lower yield of cotton. Maximum mean percent infestation of spotted bollworm (4.90) and pink bollworm (2.21) was observed in untreated conventional cotton whereas comparatively less damage was investigated in biocontrol treated conventional cotton (1.72 and 0.88). Significantly higher yield in kg/ha was recorded in biocontrol treated Bt cotton (3657) followed by in insecticide treated Bt cotton (3457). Lowest yield in kg/ha was calculated in untreated conventional cotton (2083) which was obviously due to heavy infestation of sucking pests and bollworms. It was followed by untreated Bt cotton (2966) where sucking pests infestation was high. Comparatively biocontrol treated Bt cotton produced significant results in term of least infestation by sucking pests and maximum yield.

The results indicated that transgenic Bt cotton proved not to be effective against sucking insect pests and additional control methods were needed to suppress these pests. Biocontrol agents appeared to be the most successful where least invasion by sucking pests in both Bt and non Bt cotton was observed. The current and previous studies (Men *et al*. [13]; Bambawale *et al*. [14]) reported that transgenic Bt cotton had no impact on the sucking pest population and consequently required suitable management strategies. Previous field studies by Abro *et al*., [15] and Naveen *et al*., [16] investigated the higher infestation of thrips, jassids and whiteflies in Bt cotton as compared to conventional cotton. However, Sharma and Pampapathy [17] found no significant difference of jassid and whitefly population between transgenic Bt and non-Bt cotton. In the present study the release of biocontrol agent (*C. carnea*) has a significant impact on the population of cotton bollworm and other sucking pests which is in agreement with Hanumantharaya *et al*., [18] who reported that release of *C. carnea* reduced the sucking pests (leaf hopper, thrips, aphids and white flies) and boll worms infestation and increased the cotton yield in treated plots. Kulkarni *et al*. [19] investigated that the release of *C. carnea* and other biocontrol agents in cotton field at different intervals gave significant reduction of *H. armigera* and other sucking pests. In our study insecticide (Confidor) significantly reduced sucking pest infestation which is in agreement with the investigations carried out

Table 1. Insect pest management of Bt cotton through the manipulation of different eco-friendly techniques.

Treatments	Jassids/leaf	Thrips/leaf	Whit flies/leaf	PBW infestation %	SBW infestation %	Yield kg/ha
Bio-control + Bt cotton	0.29 D	1.09 B	0.33 C	0.00 C	0.00 C	3657 A
Colour traps + Bt cotton	0.65 B	1.50 B	0.47 B	0.00 C	0.00 C	3241 C
Insecticide + Bt cotton	0.53 BC	0.97 B	0.40 BC	0.00 C	0.00 C	3457 B
Bt cotton alone	0.93 A	2.79 A	0.78 A	0.00 C	0.00 C	2966 D
Bio-control+ Conventional	0.41 CD	0.95 B	0.35 C	0.88 B	1.72 B	3024 D
Conventional alone	0.97 A	2.63 A	0.82 A	2.21 A	4.90 A	2083 E
LSD	0.22	0.55	0.10	0.38	1.28	129.45

Means followed by different letters are significantly different among each other ($p<0.05$).

PBW: pink bollworm SBW: spotted bollworm.

by various scientists [20,21]. They found that Confidor was very effective against sucking insect pests of cotton. However looking at the ill effects of pesticides, research should be focused on other alternatives that do not present the same problems. Bollworms infestation was recorded in non Bt cotton only as Bt cotton effectively escaped the attack of lepidopterous pests due to presence of Bt toxins. These results agreed with that of Arshad *et al*., [22] who reported that transgenic Bt cotton can effectively control specific lepidopterous species but lack resistant against sucking complex which is one of the major factors responsible for lower yield of cotton.

3.2. Population of Natural Enemies

One factor of particular interest in this study was to find out the impact of transgenic cotton on the population dynamics of natural enemies. Data on the establishment of released natural enemies revealed (Table 2) that mean population of eggs of *C. carnea* per 5 plants was maximum in biocontrol treated Bt cotton (0.87) which was statistically at par with biocontrol treated conventional cotton (0.79) but significantly higher than all other treatment. The reason for this variation is that frequent releases were made in biocontrol treated plot resulting in build up of their population in these plots and subsequent control of different insect pests. Mean larval population of *C. carnea* was also outstanding in biocontrol treated Bt (0.33) and non Bt cotton (0.31) and was significantly higher than the rest of treatments. Adults of *C. carnea* were also recorded higher in biocontrol treated Bt (0.29) and non Bt cotton (0.26) which were again significantly higher than all other treatments. *T. chilonis* were not released in transgenic cotton plots because of no bollworm infestation. In non Bt cotton maximum percent parasitism by *Trichogramma* was recorded where frequent releases were made (13.53). Lowest percent parasitism (1.85) was observed in untreated conventional cotton where no parasitoids were released.

Different research studies on commercialized Bt crops indicate that the expressed toxins are fatal to the target insects but do not have any direct effect on non target species (O'Callaghan *et al.,* [23]). Pilcher et al., [24] conducted a number of experiments to find out the impact of Bt crops on insect predators. None of these studies have found any adverse impacts of Bt on the survival or development of various insect predators which suggested that Bt crops are quite compatible with bio control agents and have no negative effect on important natural enemies. Unlike these studies, Hilbeck et al., [25] performed a number of laboratory studies on C. carnea, feeding on lepidopteron larvae that had fed on Bt corn. They reported higher mortality and slower development of lacewings exposed to Bt-intoxicated insects. Contrary to this, other studies by Al-Deeb et al., [26] reported no effect when feeding on Bt-intoxicated prey.

Table 2. Population of natural enemies .

Treatments	C. carnea eggs/5plts	C. carnea larvae/5plts	C. carnea adults/5plts	% parasitism (*Trichogramma*)
Bio-control+Bt cotton	0.87 A	0.33 A	0.29 A	0.00 C
Colour traps + Bt cotton	0.20 B	0.066B	0.12 B	0.00 C
Insecticide + Bt cotton	0.12 B	0.08 B	0.10 B	0.00 C
Bt cotton alone	0.18 B	0.11 B	0.09 B	0.00 C
Bio-control+ Conventional	0.79 A	0.31 A	0.26 A	13.53 A
Conventional alone	0.19 B	0.09 B	0.093B	1.85 B
LSD	0.15	0.083	0.041	0.122

Means followed by different letters are significantly different among each other ($p<0.05$)

4. Conclusions

It is concluded from the present research findings that frequent releases of biocontrol agents directly into cotton field can produce dramatic results provided growers switch from broad-spectrum pesticides. Furthermore, transgenic cotton is a bio-control friendly technology. It has no negative impact on natural enemies and effectively preserves local population of various important bio-control agents.

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