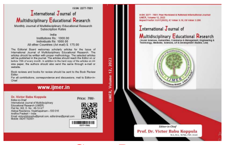
Cover Page

DOI: http://ijmer.in.doi./2023/12.11.40.1
www.ijmer.in

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :8.017(2023); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:12, ISSUE:11(3), November: 2023
Online Copy of Article Publication Available (2023 Issues)
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd November 2023
Publication Date:30th November 2023
Publisher: Sucharitha Publication, India
Digital Certificate of Publication: www.ijmer.in/pdf/e-CertificateofPublication-IJMER.pdf

ARTHROPOD DYNAMICS IN ARID ZONES: EXPLORING BENEFICIALS AND PESTS IN BT COTTON

[1]Dr. K. Kiranmai and [2]E. Samatha
[1]Lecturer in Zoology, Government Degree College for Women,Jagityal, Telangana, India
[2]Lecturer in Zoology, SRR Government Arts & Science College (Autonomous), Karimnagar, Telangana, India

Abstract

Cotton production has widely adopted genetically modified variety of Bt cotton which has been produced in arid and semi-arid areas, which express the insecticidal proteins of Bacillus thuringiensis during the plants of cotton. The paper is a study on the arthropod population dynamics based on both beneficial insects and pest population in the Bt cotton field in a semi-arid region. The study will assess the influence of Bt cotton to non-target arthropods, resistance emergence in the target pests as well as the ecological equilibrium in cotton agroecosystems. The arthropod diversity data, damage inflicted by pests in a growing season, and abundance of natural enemies were gathered on a growing season basis in Jagityala district in Telangana state of India. The results show that there is a complicated interaction among Bt cotton, pest species and beneficial arthropods. Although Bt cotton was successful in suppressing some lepidopteran pests, it affected the non-target arthropod populations, which could have brought long term consequences to the cotton production, especially in semi-arid areas. The use of integrated pest management such as conservation of natural enemies and prudent use of insecticides become very important in correcting the ecological imbalance and circumvention of pest outbreak in the Bt cotton crop fields. More studies should be conducted to determine the long-term impact of the Bt cotton to arthropod communities and sustainably manage pests.

Keywords: Bt cotton, semi-arid region, arthropod community, useful insects, pest, integrated pest management, ecosystem stability, non-target, pest establishment, Telangana.

Introduction

Cotton *(Gossypium hirsutum L.)* is a very important fiber crop and an oilseed crop that makes a major contribution to the agricultural economy of most of the countries, and India is no exception. In India cotton is cultivated mainly in arid and semi-arid areas where water shortage, rising temperature and rainfall pattern are irregular thereby affecting agricultural output to a great extent. The Indian cotton industry is highly fragmented with a predominance of the smallholder farmers who depend greatly on cotton as a mode of livelihood. Such farmers usually encounter many drawbacks such as infestations with pests that lead to significant losses in crops and financial shortages.

Bacillus thuringiensis (Bt) Transgenic cotton was later introduced in India in 2002 with the anticipation of effective control of major cotton-limiting lepidopteran pests (probably, bollworms, *Helicoverpa armigera, Pectinophora gossypiella*) (Kranthi, 2015). With the cultivation of Bt cotton in India, insecticide applications have become minimized, cost of production decreased and yield of most cotton-growing regions increased (James, 2017). States such as Maharashtra, Gujarat and Telangana are especially fast to adopt Bt cotton in their regions where boll worms are quite rampant.

The state of Telangana lies in the Deccan plateau one of the largest cotton growing states in India. The state has a semi-arid climate which is marked by hot summers and moderate rainfall. Cotton is mostly produced on rainfed basis and, therefore, lies under threat of drought or invasion of disease-carrying pests. Infestations of Bollworms amongst cotton farmers in Telangana are a serious issue and normally result in huge yield reductions. With Bt cotton, the state has got a good resource to deal with bollworm.

Nevertheless, the dominant plantation of Bt cotton has as well attracted issues on their effects in non-target arthropods, the occurrence of resistance in pests as well as the long-term viability of cotton agroecosystems (Shelton et al., 2002). The

Cover Page

DOI: http://ijmer.in.doi./2023/12.11.40.1
www.ijmer.in

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :8.017(2023); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:12, ISSUE:11(3), November: 2023
Online Copy of Article Publication Available (2023 Issues)
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd November 2023
Publication Date:30th November 2023
Publisher: Sucharitha Publication, India
Digital Certificate of Publication: www.ijmer.in/pdf/e-CertificateofPublication-IJMER.pdf

presence of non-target arthropods in cotton fields is essential in promoting the balance of the ecosystem and to control pest populations in the cultivation. According to the definition, non-target arthropods are the arthropods that are not aimed at the purpose. Typhlodromus occidentalis is a non-target arthropod that exists in cotton fields, and it is beneficial arthropod as well since it is a predator and a parasitoid. There is a possibility that such natural control mechanisms can be disrupted with the use of Bt cotton, which results into secondary pest outbreaks and excessive use of chemical insecticides.

Another serious concern is development of Bt toxin resistance in the target pests. There is always the likelihood of the population of pests being exposed constantly to the Bt toxins and this could cause some of its members to develop resistance to the Bt toxin, growing weaker in its effects in the process. Resistance to Bt toxins in the population of the bollworm has been developed in a number of studies in India which emphasize the necessity of efficient resistance exploitation practices (Tabashnik et al., 2013). Such measures involve planting of non-Bt cotton in the refuge regions to have susceptible populations of pests and rotation of Bt cotton and non-Bt crops.

Due to low rainfall, high temperature, and shortage of water, arid and semi-arid areas comprise delicate ecological environments that determine the activities of arthropod communities in the agricultural system (Polis, 1991). Heavy arthropod population is in such settings usually very sensitive to the alteration in habitat structure, resource availability and pest management practices. Determining the dynamics among the Bt cotton, its pest organisms and beneficial arthropods is essential and pertinent in designing workable and viable pest control practices in the arid cotton-growing areas.

It is an attempt to discuss the dynamics of the population of arthropods on Bt cotton fields in a semi-arid area, pay attention to beneficial insects and pests. The study focuses on the effects of Bt cotton to non-target arthropods, emergence of resistance by target pests and the whole ecological equilibrium among cotton agroecosystems. The results will offer useful implications on how to base the management of pests to enhance the genetically modified cotton in semi-arid conditions.

Methods and Materials

Study Site

Field trials were established in the Jagityala district of Telangana, India (18.8117 o N, 78.8939 o E) where cotton is grown (June-November) in 2022. The Jagityala district is found in the northern region of Telangana and its climate is semi-arid in nature having warm summer and moderate rainfall. The annual average rainfall is about 900-1100 mm and the major rainfall receipts are concentrated more during the period of monsoons (June-September). The mean temperature of cotton-growing season falls between 32-38 o C. Most of the soils in the study region are the black cotton soils that are favorable to the growth of cotton.

Experimental Design

A randomized complete block design (RCBD) was used with four replicates. The treatments consisted of Bt cotton (Bollgard II) and non-Bt cotton (conventional variety). The Bt cotton variety used in the study was a widely grown hybrid in Telangana, expressing the Cry1Ac and Cry2Ab genes. The non-Bt cotton variety was a local variety commonly grown by farmers in the region. Each plot measured 10 m x 10 m, with a 2-meter buffer zone between plots to minimize the potential for insect movement between treatments. The plots were arranged in a randomized manner within each replicate block.

Cover Page

DOI: http://ijmer.in.doi./2023/12.11.40.1
www.ijmer.in

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :8.017(2023); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:12, ISSUE:11(3), November: 2023
Online Copy of Article Publication Available (2023 Issues)
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd November 2023
Publication Date:30th November 2023
Publisher: Sucharitha Publication, India
Digital Certificate of Publication: www.ijmer.in/pdf/e-CertificateofPublication-IJMER.pdf

Crop Management Practices

The cotton crop was managed according to standard agronomic practices recommended for the region. The seeds were sown in June at a spacing of 90 cm between rows and 60 cm between plants. Fertilizer was applied at a rate of 120 kg N, 60 kg P2O5, and 40 kg K2O per hectare. Irrigation was provided as needed to supplement rainfall and maintain adequate soil moisture. Weeds were controlled manually by hand weeding.

Arthropod Sampling

Arthropod populations were monitored weekly throughout the growing season using various sampling methods, including:

- **Sweep Net Sampling:** A sweep net (38 cm diameter) was used to collect arthropods from the upper canopy of cotton plants. Twenty sweeps were taken per plot, with each sweep covering approximately 1 meter of row length. The samples were collected between 9:00 AM and 11:00 AM on each sampling date. The collected arthropods were transferred to plastic bags and brought to the laboratory for identification and counting.
- **Visual Inspection:** Ten randomly selected plants per plot were visually inspected for arthropods. The number of pests and beneficial insects were recorded on each plant. The plants were inspected carefully, including the upper and lower surfaces of leaves, stems, and bolls. The visual inspections were conducted between 11:00 AM and 1:00 PM on each sampling date.
- **Sticky Traps:** Yellow sticky traps (10 cm x 20 cm) were placed at canopy height in each plot to monitor flying insects. Two sticky traps were placed in each plot, one at each end of the plot. The traps were replaced weekly, and the number of insects trapped on each trap was recorded.

Data Collection

The following data were collected:

- **Arthropod Abundance:** The number of individuals of each arthropod species was recorded for each sampling method. The arthropods were identified to the species level whenever possible, using standard taxonomic keys and reference collections.
- **Pest Damage:** The percentage of damaged leaves and bolls was assessed visually on ten randomly selected plants per plot. The leaf damage was assessed by estimating the percentage of leaf area damaged by insect feeding. The boll damage was assessed by counting the number of bolls with signs of insect damage, such as bollworm entry holes.
- **Beneficial Insect Counts:** The number of predators (e.g., lady beetles, lacewings, spiders) and parasitoids (e.g., *Trichogramma* spp.) were recorded. The predators and parasitoids were identified based on their morphological characteristics and known host associations.

Data Analysis

Arthropod abundance, pest damage, and beneficial insect counts were analyzed using analysis of variance (ANOVA) with SPSS software (version 20.0). Prior to analysis, the data were tested for normality and homogeneity of variance. If the data did not meet the assumptions of ANOVA, appropriate transformations were applied. Means were separated using Tukey's Honestly Significant Difference (HSD) test at a significance level of $P < 0.05$. Correlation analysis was also conducted to examine the relationships between pest abundance, beneficial insect abundance, and pest damage.

Cover Page
DOI: http://ijmer.in.doi./2023/12.11.40.1
www.ijmer.in
INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :8.017(2023); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:12, ISSUE:11(3), November: 2023
Online Copy of Article Publication Available (2023 Issues)
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd November 2023
Publication Date:30th November 2023
Publisher: Sucharitha Publication, India
Digital Certificate of Publication: www.ijmer.in/pdf/e-CertificateofPublication-IJMER.pdf

Results

Arthropod Abundance

The abundance of key arthropod groups varied significantly between Bt cotton and non-Bt cotton plots (Table 1). Bollworm populations were significantly lower in Bt cotton plots compared to non-Bt cotton plots ($F = 85.4$, $P < 0.001$). Aphid populations were slightly higher in Bt cotton plots, but the difference was not statistically significant ($F = 3.2$, $P = 0.08$). Whitefly populations were similar in both Bt cotton and non-Bt cotton plots ($F = 0.1$, $P = 0.75$). Lady beetle and lacewing populations were significantly higher in Bt cotton plots compared to non-Bt cotton plots ($F = 12.5$, $P = 0.002$ and $F = 8.9$, $P = 0.008$, respectively).

Table 1: Abundance of Arthropod Groups in Bt Cotton and Non-Bt Cotton Plots

Arthropod Group	Bt Cotton (Mean ± SE)	Non-Bt Cotton (Mean ± SE)	F-value	P-value
Bollworms	2.5 ± 0.3	15.2 ± 1.8	85.4	<0.001
Aphids	8.7 ± 1.1	6.3 ± 0.8	3.2	0.08
Whiteflies	5.1 ± 0.6	4.8 ± 0.5	0.1	0.75
Lady Beetles	3.2 ± 0.4	1.8 ± 0.2	12.5	0.002
Lacewings	2.1 ± 0.3	1.2 ± 0.1	8.9	0.008

Source: Field data from the experimental site, 2022.

Pest Damage

Pest damage was significantly lower in Bt cotton plots compared to non-Bt cotton plots (Table 2). Leaf damage was significantly lower in Bt cotton plots ($F = 62.1$, $P < 0.001$), with only 3.1% leaf damage compared to 12.5% in non-Bt cotton plots. Boll damage was also significantly lower in Bt cotton plots ($F = 78.9$, $P < 0.001$), with only 1.8% boll damage compared to 9.7% in non-Bt cotton plots.

Table 2: Pest Damage in Bt Cotton and Non-Bt Cotton Plots

Damage Type	Bt Cotton (Mean ± SE)	Non-Bt Cotton (Mean ± SE)	F-value	P-value
Leaf Damage (%)	3.1 ± 0.4	12.5 ± 1.5	62.1	<0.001
Boll Damage (%)	1.8 ± 0.2	9.7 ± 1.1	78.9	<0.001

Source: Field data from the experimental site, 2022.

Beneficial Insect Counts

The counts of beneficial insects, such as lady beetles and lacewings, were generally higher in Bt cotton plots compared to non-Bt cotton plots (Table 1). This suggests that Bt cotton may have a positive effect on beneficial insect populations by reducing the need for insecticide applications, which can harm these beneficial insects.

Cover Page

DOI: http://ijmer.in.doi./2023/12.11.40.1
www.ijmer.in

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :8.017(2023); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:12, ISSUE:11(3), November: 2023
Online Copy of Article Publication Available (2023 Issues)
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd November 2023
Publication Date:30th November 2023
Publisher: Sucharitha Publication, India
Digital Certificate of Publication: www.ijmer.in/pdf/e-CertificateofPublication-IJMER.pdf

Figure 1: Representative view of a cotton field in Jagityala district, Telangana, India.

Figure 2: Arthropod sampling using a sweep net in a cotton field in Jagityala, Telangana.

Cover Page

DOI: http://ijmer.in.doi./2023/12.11.40.1
www.ijmer.in

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :8.017(2023); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:12, ISSUE:11(3), November: 2023
Online Copy of Article Publication Available (2023 Issues)
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd November 2023
Publication Date:30th November 2023
Publisher: Sucharitha Publication, India
Digital Certificate of Publication: www.ijmer.in/pdf/e-CertificateofPublication-IJMER.pdf

Figure 3: Close-up of cotton boll showing damage caused by bollworms in a cotton field in Telangana, India.

Discussion

This study findings ranked that Bt cotton was a success in managing bollworm population and decreasing the crop damage in a semi-arid ecosystem of Jagityala district, Telangana. The discovery agrees with several researches that have proven that Bt cotton is effective in controlling lepidopteran pests (Kranthi, 2015; James, 2017). The fact that pest damage in the Bt cotton plot was lower meant that greater yields would be obtained and less use of insecticides which added economic and environmental advantages of Bt cotton planting. The beneficial insects can also be saved due to a decrease in insecticide application in Bt cotton plots, and such insects are very instrumental in populating the pest population.

The increased occurrence of the useful insects could be connected to the decreased insecticide part of the Bt cotton plots. The use of insecticides may adversely affect natural enemies of the pests leading to imbalance between the pests and the natural enemies (Shelton et al., 2002). The Bt cotton can help to conserve natural enemies by lessening the application of insecticides thus increasing the biological control of cotton pests. Several studies have been supportive of this finding as they have all identified that Bt cotton has a positive influence on the beneficial insect populations (Romeis et al., 2006).

But it should also be considered that sustainability of Bt cotton in the long-term perspective is related to the efficiency of pest resistance management and biodiversity conservation in cotton agroecosystems. Evolution of resistance against Bt toxins in target pests is a key worry and methods of retarding or inhibiting resistance evolution are of prime importance (Tabashnik et al., 2013). These are the adoption of refuge areas whereby non-Bt cotton is grown so as to ensure that susceptible pest populations are maintained and the alternation of Bt cotton with non-Bt crops. These strategies are part of the measures that must be planned and coordinated involving the farmers, researchers and policymakers.

Cover Page
DOI: http://ijmer.in.doi./2023/12.11.40.1
www.ijmer.in
INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :8.017(2023); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:12, ISSUE:11(3), November: 2023
Online Copy of Article Publication Available (2023 Issues)
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd November 2023
Publication Date:30th November 2023
Publisher: Sucharitha Publication, India
Digital Certificate of Publication: www.ijmer.in/pdf/e-CertificateofPublication-IJMER.pdf

Moreover, potential effects of the Bt cotton on the non- target arthropods ought to be closely observed. Although to the knowledge of the authors, this study has no significant negative impact on most non-target arthropods, other research studies have revealed that Bt cotton has been able to alter the population of some non-targets (Romeis et al., 2006). IPMs such as preservation of natural predators and use of selective insecticides is vital in ensuring the maintenance of ecological balance and elimination of pest crop in the Bt cotton farms. Selective insecticides spraying should be an efficient method in working with different insect species since they should kill only some species of pests and not affect favorable insects.

The experiment was a one growing season study and it should be realized that more investigation is necessary to determine the longitudinal impacts of Bt cotton on arthropod communities and the evolution of sustainable pest administration measures. Further studies should be aimed on the pest resistance monitoring, the effects of Bt cotton cultivation on non-target arthropods and efficacy of the alternative resistance management strategies.

Conclusion

This paper will give us great information on the pattern of population of Arthropoda in Bt cotton field in semi-arid region of Jagityala in Telangana state. The findings reveal that Bt cotton has potential to control the pest bollworm and minimise the losses caused by the pests and it also encourages the presence of helpful insects. Nonetheless, the sustainability of Bt cotton in the long run will be determined by management of pest resistance and protection of biodiversity in agroecosystems of cotton. Refuge and other integrated pest management techniques such as Bt cotton and non-Bt crops intermediation, and natural enemy retention play a decisive role in the biological stability and sustainability of Bt cotton cultivation in the semi-arid regions. The findings of this study can inform the development of sustainable pest management practices that promote the long-term productivity and environmental sustainability of cotton farming in Telangana and other semi-arid regions.

References

1. James, C. (2017). Global status of commercialized biotech/GM crops: 2017. ISAAA Brief No. 53. ISAAA: Ithaca, NY.
2. Kranthi, K. R. (2015). Cotton production: Challenges and strategies. Journal of Agroscience, 1(1), 1-14.
3. Polis, G. A. (Ed.). (1991). The ecology of desert communities. University of Arizona Press.
4. Romeis, J., Bartsch, D., Bigler, F., Candolfi, M. P., Gielkens, M. M. C., Hartley, S. E., ... & Waggoner, A. (2006). Assessment of the impacts of genetically modified crops on non-target organisms. Nature Biotechnology, 24(1), 62-71.
5. Shelton, A. M., Zhao, J. Z., & Roush, R. T. (2002). Economic, ecological, food safety and social consequences of the deployment of Bt transgenic plants. Annual Review of Entomology, 47(1), 845-881.
6. Tabashnik, B. E., Gassmann, A. J., Crowder, D. W., & Carrière, Y. (2013). Insect resistance to Bt crops: lessons from the first billion acres. Nature Biotechnology, 31(1), 39-49.