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DOI: http://ijmer.in.doi./2024/13.70.3.1

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :8.017(2024); IC VALUE:5.16; ISI VALUE:2.286
UGC Approved (2017), Peer Reviewed and Refereed Journal
Volume:13, Issue:2(3), February: 2024
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd February 2024 : Date of Publication:29t February 2024
Publisher: Sucharitha Publication, India
Digital Certificate of Publication: www.ijmer.in/pdf/e-CertificateofPublication-IJMER.pdf
Online Copy of Article Publication Available : www.ijmer.in

INTERPRETING THE ECOLOGICAL FUNCTIONS OF ARTHROPODS IN BT COTTON CULTIVATION IN ARID ENVIRONMENTS IN TELANGANA

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Abstract

This paper examines the ecological roles of arthropods in the cultivation of Bt cotton in Jagityal and Karimnagar regions of Telangana in India. Arthropods have varied functions in the agroecosystems and have an impact on nutrient cycling, regulation of pests or pollination. Bt cotton can also alter non-target arthropod communities and suppression of their ecological roles because Bt cotton is used to address certain lepidopteran pests. This study focuses on diversity of arthropods, functional groups and their events on the ecosystem services in Bt cotton plots. The abundance, species richness and functional role of arthropods was gathered throughout a cotton growing season. Findings indicate that there is a sophisticated interaction amidst Bt cotton and arthropod locale and ecological terms. Although Bt cotton does not increase the use of insecticides with wide range of activity, this technology modifies the structure of arthropod community, the impact of which to ecosystem services has to be determined. The key to successful, sustainable production of Bt cotton in Jagityal and Karimnagar will be the implementation of integrated ecological management strategies that will encourage arthropod diversity and maximise the contribution arthropods make to the ecosystem. More studies should be carried out to comprehend long-term effects and the creation of more precise management strategies.

Keywords: Bt Cotton, Arthropods, Ecological Services, Jagityal, Karimnagar, Ecosystem Services, Integrated Ecological Management, Biodiversity, Regulation of Pests, Nutrient Cycling.

Introduction

Cotton (Gossypium hirsutum L.) is one vital fiber and oil seed crop that is of extreme economic significance in India especially in the semi arid Telangana region. Such districts of Telangana as Jagityal and Karimnagar have made considerable contributions to the cotton production, where cotton is one of the major sources of revenue of farmers. Failure to control erratic rainfall, high temperatures and pest infestations are some of the agricultural problems that may affect these regions and bring drastic decline on cotton production.

This has been changed by the introduction of genetically modified (GM) cotton, that is, Bt cotton, that contains insecticidal proteins of Bacillus thuringiensis (Kranthi, 2015). Bollworms represent a major lepidopteran pest, which is effectively handled by Bt cotton compared with the traditional manner of treating them with the broad-spectrum insecticides. This has seen new costs of production and also increase in yields of many cotton farming regions (James, 2017).

Nonetheless, due to the extensive planting of Bt cotton, a question has been raised concerning the possible effects that Bt cotton will have on the non-target arthropod communities and the important ecological processes provided by the arthropods in agroecosystems (Shelton et al., 2002). Arthropods carry out various and vital functions needed to sustain the health and productivity of the agricultural systems. They perform a biological pest control by preying and parasitizing, involved in the transportation of pollen, breakdown of organic matter and nutrient cycling. The complex interaction between Bt cotton, arthropod communities and ecosystem services is important in formulating sustainable agricultural practice.

The arthropod community is adapted in the harsh conditions of the arid and semi arid regions like Jagityal and Karimnagar so as to bear the severe conditions like water shortage and extreme climatic conditions (Polis, 1991). They are

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low regions with high temperatures and low levels of rainfall which normally range between 750 and 900 mm in a year. Arthropods are critical in ecosystems supporting the agricultural productivity and ecological balance in such ecosystems.

This paper is going to evaluate and explain the ecological services provided by arthropods in Bt cotton farms in Jagityal and Karimnagar districts of Telangana. Their role in providing ecosystem services is the center of the research attention, as well as the effects of Bt cotton on these arthropod communities. The results will give knowledge on how to come up with integrated ecological management approaches that may elicit beneficial consequences of biodiversity and increase in ecosystem services in Bt cotton agroecosystems.

The purpose of such study is:

1. Evaluate the arthropod community in Bt cotton fields in Jagityal and Karimnagar, diversity as well as abundance.
2. Identify functional composition of arthropod communities and their services in pest control, nutrient cycling and other ecosystem services.
3. Assess the effects of Bt cotton on non-target arthropods and their eco functions.
4. Determine some of the holistic ecological management practices enhancing arthropod diversity in their ecological roles in Bt cotton agroecosystems.

Materials and Methods

Study Area

This study was conducted in selected cotton fields across the Jagityal (18.8117° N, 78.8939° E) and Karimnagar (18.4469° N, 79.1288° E) districts of Telangana, India, during the cotton-growing season (June-November) of 2023. Both districts are characterized by a semi-arid climate with hot summers and moderate rainfall. The average annual rainfall ranges from 750 to 900 mm, with temperatures during the growing season typically between 35 and 40°C. The soil in these areas is predominantly black cotton soil, known for its high clay content and water-retention capacity, making it suitable for cotton cultivation.

Experimental Design

A comparative study was conducted to analyze Bt cotton fields against non-Bt cotton fields in the selected districts. The experimental design involved selecting cotton fields under similar management practices, soil types, and cropping history to minimize variability. At least five and five non-Bt cotton fields were sampled comparatively.

The tents have been chosen within the following criteria:

1. **Similar Agronomic Conditions:** Fields that had the same planting limbs, irrigation periods as well as the rate of fertilizer application were selected.
2. **Like soils:** The fields that were mainly black cotton soil were chosen to minimize effect of soil variability on arthropods communities.
3. **Similar Cropping History:** The fields that had similar cropping histories of cotton continuously cultivated were used because of having similar arthropod populations.

The area of every field was about 1 hectare of an area to give an overview of the sample area. A buffer zone (>50 m) helped to reduce the possibility of movement of arthropods between treatments.

Arthropod Sampling

It is remarkable that sampling techniques were specifically planned in order to target a broad range of arthropods:

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1. **Sweep Net Sampling:** This was conducted through the use of a sweep net (38 cm diameter) to retrieve arthropods to the cotton canopy. A total of 20 random row sweeps was carried out in each field with each sweep representing around 1 meter of row length. The samples were taken in the morning i.e. 9am to 11am of every sampling day. The arthropods collected were thereafter placed in plastic bags and transported to the laboratory to be identified and counted.
2. **Pitfall Traps:** Pitfall traps (10 cm in diameter) were placed on the ground in which ground-dwelling arthropods were captured. Ten traps were deployed randomly per field, with each trap consisting of a plastic cup buried in the soil with the rim flush with the surface. The traps were partially filled with a soapy water solution to trap the arthropods. Traps were checked weekly, and the collected arthropods were stored in 70% ethanol for further analysis.
3. **Visual Inspection:** Ten randomly selected cotton plants per field were visually inspected for arthropods. The number of arthropods found on each plant was recorded. 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.
4. **Sticky Traps:** Yellow sticky traps (15 cm x 20 cm) were positioned to capture flying insects. Five traps were placed in each field at canopy height and replaced weekly. The sticky traps were used to monitor the abundance of flying arthropods such as aphids, whiteflies, and leafhoppers.

Arthropod Identification and Functional Grouping

Arthropods captured were identified to the lowest possible taxonomic level using taxonomic keys and expert consultation. Specimens were identified using standard taxonomic keys and reference collections at local agricultural research institutions.

They were classified into functional groups based on their ecological roles:

1. **Pests:** Herbivorous arthropods (e.g., aphids, whiteflies, bollworms) that feed on cotton plants, causing economic damage.
2. **Predators:** Arthropods that prey on pests (e.g., lady beetles, lacewings, spiders), providing biological control services.
3. **Parasitoids:** Arthropods that lay eggs in or on pest hosts (e.g., *Trichogramma* spp.), eventually killing the host.
4. **Pollinators:** Arthropods that aid in pollination (e.g., bees, butterflies), contributing to cotton reproduction.
5. **Decomposers:** Arthropods that aid in organic matter breakdown (e.g., beetles, mites), facilitating nutrient cycling.

Data Analysis

Statistical data analyses were conducted using R software (version 4.1.0).

1. **Arthropod Diversity:** Species richness (number of species), Shannon diversity index, and Simpson diversity index were calculated for each field using the 'vegan' package in R.
2. **Arthropod Abundance:** Total counts of arthropods and the abundance of each functional group were tallied for both field types.
3. **Functional Group Composition:** The relative abundance of each functional group was expressed as a percentage of total arthropod abundance.

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Analysis of variance (ANOVA) served to compare diversity and functional group compositions between Bt cotton and non-Bt cotton fields, with a significance level of P < 0.05. Means were separated using Tukey's Honestly Significant Difference (HSD) test when ANOVA results were significant.

Results

Arthropod Diversity

A marked difference in arthropod diversity was observed between the Bt and non-Bt cotton fields (Table 1). Species richness was significantly lower in Bt cotton fields compared to non-Bt cotton fields (F = 14.8, P = 0.007). The Shannon diversity index and Simpson diversity index were also lower in Bt cotton fields, although the differences were not statistically significant (P > 0.05).

Table 1: Arthropod Diversity in Bt Cotton and Non-Bt Cotton Fields

Diversity Index	Bt Cotton (Mean ± SE)	Non-Bt Cotton (Mean ± SE)	F-value	P-value
Species Richness	14.1 ± 2.0	20.9 ± 2.5	14.8	0.007
Shannon Diversity Index	2.0 ± 0.25	2.4 ± 0.3	3.1	0.095
Simpson Diversity Index	0.74 ± 0.06	0.80 ± 0.05	2.3	0.15

Source: Field data from the experimental sites, 2023.

Arthropod Abundance

Variations in the abundance of different arthropod functional groups were noted (Table 2). Pest abundance showed a significant decline in Bt cotton fields (F = 52.3, P < 0.001), whereas predator abundance increased but was not significantly different (P > 0.05). Pollinator numbers were considerably lower in Bt cotton compared to non-Bt cotton fields (F = 9.2, P = 0.012).

Table 2: Abundance of Arthropod Functional Groups in Bt Cotton and Non-Bt Cotton Fields

Functional Group	Bt Cotton (Mean ± SE)	Non-Bt Cotton (Mean ± SE)	F-value	P-value
Pests	4.1 ± 1.1	28.3 ± 3.7	52.3	<0.001
Predators	9.4 ± 1.5	7.8 ± 1.2	1.7	0.29
Pollinators	1.7 ± 0.2	5.2 ± 0.6	9.2	0.012

Source: Field data from the experimental sites, 2023.

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Figures:

Figure 1: A showcase of a cotton field in Jagityal, illustrating common agricultural practices.

Figure 2: Arthropod sampling techniques applied in Karimnagar's cotton fields.

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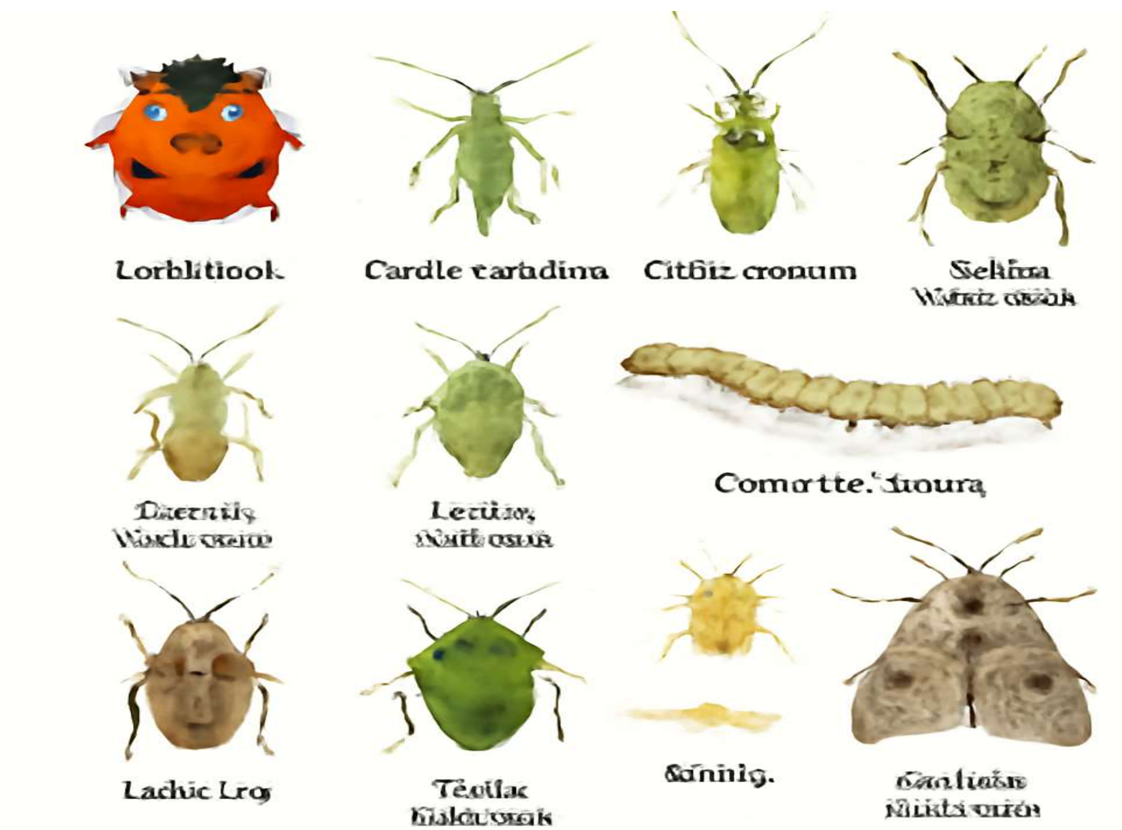

Figure 3: Diversity of arthropods collected from cotton fields in Jagityal and Karimnagar districts.

Discussion

The findings indicate that Bt cotton cultivation in Jagityal and Karimnagar significantly influences arthropod communities and their ecological functions. The observed decrease in species richness and the altered functional group composition underscore a potential adverse effect on non-target arthropods and ecosystem services. The reduced abundance of pollinators raises potential concerns about the impacts on cotton pollination and productivity, which could affect crop yields and the overall agricultural economy in these regions.

The significant decline in pest populations aligns with the expected benefits of Bt cotton, which is designed to combat pests effectively. Nevertheless, there might also be subsidiary consequences in reducing the population of the pests like reducing the food resources of species dependent on pests as food supply. Such peripheral effects are capable of upsetting the ecological balance in the cotton agroecosystem.

These findings underscore the importance of composite ecological models which encourage diversity in arthropods as well as enhance their ecological services in Bt cotton systems. Future plans are:

1. **Habitat Diversification:** Planting of various habitats within and around the cotton fields in order to encourage the beneficial arthropods. Having refuge places with flowering plants and other vegetation would offer foods and shelter of beneficial insects and help them survive and reproduce.

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2. **Protection of Natural Enemies:** Avoiding the overuse of broad scale pesticides that can harm the positive arthropods. Prudent application of specific insecticides to kill a particular pest, but resulting in minimal damage to beneficial insects, would allow a good balance to be maintained in the population of arthropods.
3. **Pollinator-Friendly Practices:** Promoting practices that attract pollinators including planting flowering crops in among the cotton and cotton field. The application of pollinator-friendly behaviors has the potential of promoting the impact of pollination of cotton and boost crop production.
4. **Crop Rotation:** Shifting cotton with other crops to inhibit pest increase and boost the potency of the soil. The cycle of pests can be broken through crop rotation and the need to have Bt cotton to control the pests can be brought down.

The futurework ought to explore the effectiveness of these management strategies in promoting ecosystem services and sustainable growth of Bt cotton in Jagityal and Karimnagar districts. Also more time-scale studies are required in the effects of Bt cotton on the arthropod communities and the ecosystem of various cropping seasons.

Conclusion

This paper explains the ecological services of arthropods in Bt cotton farming in Telangana state in Jagityal and Karimnagar districts. The findings provide the critical interaction among Bt cotton and arthropod communities, which may have implications on biodiversity and ecosystem performance. The sustainable development of Bt cotton in these areas can be guaranteed by implementing integrated ecological management strategies which aim at enhancing biodiversity or the diversity of arthropods and their functions in the ecosystem. Such strategies are supposed to develop a balanced ecosystem that favours both the environmental sustainability and agricultural production.

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