E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(6): 31-35
Received: 18-03-2024
Accepted: 23-04-2024

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Exploring pest, disease, and weed dynamics in cotton cultivation & assessing the field efficacy of biopesticides and the impact of food spray on beneficial insects in Dhule and Nandurbar districts, Maharashtra

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i6Sa.808

Abstract
Cotton cultivation in Maharashtra's Dhule and Nandurbar districts faces multifaceted challenges from pests, diseases, weeds, and maintaining a balance of beneficial insects. This study explores the dynamics of these biological agents and evaluates the field efficacy of biopesticides and food spray applications in managing pest pressures while promoting beneficial insect populations. Surveys conducted during the 2023-2024 Kharif season revealed variations in pest, disease, and weed prevalence across different growth stages of cotton cultivation. Biopesticides such as Neemark, Verticillium, Beauveria, and Trichoderma demonstrated significant efficacy in reducing pest infestations, while food spray applications enhanced beneficial insect populations. The findings highlight the importance of integrated pest management tailored to local agroecological conditions for sustainable agriculture and biodiversity conservation. Practical implications for farmers and stakeholders include adopting biocontrol strategies and promoting environmentally friendly pest management practices in cotton cultivation. This research contributes valuable insights to sustainable agriculture in the Dhule and Nandurbar districts and underscores the significance of holistic pest management approaches.

Keywords: Cotton cultivation, pest management, biopesticides, beneficial insects, integrated pest management, sustainable agriculture, Maharashtra, India

Introduction
Cotton farming in Maharashtra's Dhule and Nandurbar districts is deeply ingrained in local traditions and serves as a cornerstone of livelihoods while being a focal point for agricultural innovation. However, the sustainable growth and productivity of this crucial crop face persistent challenges from various fronts, including pest attacks, disease outbreaks, weed proliferation, and maintaining a delicate equilibrium among beneficial insects within the farming ecosystem (Saxena *et al*., 2021) [14]. In light of these challenges, our study aims to delve into the complex dynamics of cotton farming, with a primary focus on understanding the prevalence and severity of pests, diseases, weeds, and beneficial insects in the cotton-growing regions of Dhule and Nandurbar. Through meticulous surveys and thorough analyses, we seek to uncover the underlying factors driving the dynamics of these biological agents and their implications for crop health and yield (Sarode *et al*., 2020) [18].

Moreover, our research endeavors to evaluate the field efficacy of biopesticides as potential management tools to mitigate pest and disease pressures in cotton fields. Through rigorous experimentation and empirical observations, we aim to assess the effectiveness of biocontrol agents such as neem extract, Beauveria bassiana, Verticillium lecanii, and Trichoderma spp. In suppressing pest populations and curtailing the spread of diseases, while also minimizing adverse environmental impacts (Wawdhane *et al*., 2020) [16]. Additionally, we explore the impact of agricultural practices, specifically food spray applications, on the abundance and diversity of beneficial insects in cotton fields. By enriching food sprays with nutrients and attractants, we aim to enhance habitat and food resources for beneficial insects, thereby fostering their populations and promoting natural pest control mechanisms (Amera *et al*., 2017) [1].

The outcomes of our research are expected to yield valuable insights into the intricate interactions between pests, diseases, weeds, and beneficial insects in cotton agroecosystems. Furthermore, the findings regarding the field efficacy of biopesticides and the impacts of food spray applications hold significant implications for sustainable pest management practices and the conservation of biodiversity in agricultural landscapes (Parajuli *et al*., 2022) [9]. Ultimately, this research not only contributes to the existing body of knowledge on cotton cultivation but also holds practical significance for farmers, policymakers, and stakeholders committed to promoting sustainable agriculture and food security in the Dhule and Nandurbar districts of Maharashtra.

Materials and Methods

The study was conducted during the Kharif season of 2023-2024 in the Dhule and Nandurbar districts of Maharashtra. A randomized block design with three replications and five treatments, including a control, was employed. Individual plot sizes of 20R were maintained, and Bt hybrid cultivars were used. One botanical neem extract (Pure) and microbial agents including *Beauveria bassiana* (1 x 10^8 CFU/ml), *Verticillium lecanii* (1 x 10^8 CFU/ml), and Trichoderma viride (1 x 10^8 CFU/ml) were evaluated. The incidence of diseases, pests, weeds, and natural enemies was studied at 30, 60, 90, and 120 days after sowing.

Commercial formulations of the microbial agents were procured directly from reputable private firms, while food sprays and neem extracts were prepared in the field. Neem extract was prepared by grinding 5 kg of neem seed kernel into a powder, soaking it overnight in 10 liters of water, stirring until milky white, filtering through muslin cloth, and adjusting the volume to 100 liters. A 1% detergent solution was added to the spray mixture. Food spray preparation involved cleaning 4 kg of maize kernels, soaking them in 10-15 liters of boiling water for 24 hours, grinding, soaking again for 48 hours, filtering, drying, and finally diluting with water as a spray solution.

Twenty plants were randomly selected and tagged from each plot to serve as a representative population. Observations regarding pest incidence were conducted on these tagged plants. Specifically, three leaves per section (upper, middle, and bottom) of each selected plant were meticulously examined for the presence of nymphs and adults of sucking pests, including aphids, Jassids, thrips, and whiteflies. Percent reduction in the population of sucking pests & Pink bollworms was worked out by using the following formula.

Percent reduction= Pre-treatment Population – Post-treatment Population/ Pre-treatment Population*100

In the case of pink bollworm infestation, observations were made on square flowers and infested bolls, with the percentage reduction in the population of pink bollworms calculated using a specified formula.

Percent rosette flowers = Damaged flowers/ Total no of farmers* 100

A total of three sprays was carried out at a seven-day interval for each treatment, initiated upon pest populations reaching the economic threshold level (ETL). Pre-treatment observations were recorded 24 hours before spraying, with post-treatment observations taken after 7 days of each spraying.

For assessing wilt disease incidence, Trichoderma liquid drench application was performed, with wilt incidence monitored at 30 DAS followed by measurements 15 to 20 days post-application using a specified formula.

Wilt incidence (%) = (Total number of wilted plants / Total number of plants observed) *100

Data Analysis

"Collected data underwent thorough statistical analysis. Descriptive statistics summarized pest, disease, weed, and beneficial insect prevalence. Inferential methods like ANOVA assessed biopesticide efficacy and food spray impact. Significance level: $p<0.05$. Analysis followed standard scientific protocols for reliability."

Results and Discussion

Assessment of Pest, Disease, Beneficial Insects, and Weed Incidence in Dhule and Nandurbar Districts

Pest Incidence

- Pest incidence in both Dhule and Nandurbar districts exhibited variations throughout different growth stages of cotton cultivation.
- In Dhule, aphids (*Aphis gossypii*), Jassids (*Amrasca biguttula*), thrips (*Thysanoptera*), and whiteflies (*Aleyrodidae*) were prevalent from 0-45 days after sowing (DAS), with pink bollworms (*Pectinophora gossypiella*) infestation increasing in later stages.
- Similarly, in Nandurbar, thrips dominated in the initial stages, followed by aphids, Jassids, and mealy bugs. Subsequent stages saw the consistent presence of aphids, thrips, Jassids, and later, PBW.
- Throughout the season, sucking pests are consistently observed in both the Dhule and Nandurbar districts, indicating a persistent presence of these pests in the cotton fields.

Disease Incidence

- Fusarium wilt (*Fusarium oxysporum*) was predominant in both districts during the early stages (0-45 DAS) of cotton cultivation
- Dhule witnessed additional diseases such as leaf curl (*CLCuD*), bacterial blight (*Xanthomonas citri pv. Malvacearum*), and Alternaria leaf spot (*Alternaria* spp.) in later growth stages, while Nandurbar observed reddening and leaf curl.
- In Nandurbar, the soils exhibit deficiencies in potassium and magnesium sulfate, leading to a prolonged presence of reddening, a physiological disorder affecting the crops.

Weed Incidence

- Weed infestation was significant in both districts, with diverse weed species observed across various growth stages.
- In Dhule, common weeds included Black pigweed, Hariyali, Parthenium, Euphorbia, Sage bud, Dudhi, Kunda-smooth crabgrass, Aghada, and Kena.
- Nandurbar recorded species like Parthenium, Horseweed, and Nutgrass.
- Regarding weed incidence, the Nandurbar district experiences a higher prevalence of Horseweed and Nutgrass compared to Dhule. However, both districts commonly encounter weeds such as Black pigweed, Hariyali, Parthenium, Euphorbia, Sage bud, Dudhi, Kunda- Smooth crabgrass, Aghada, and Kena.

- Common weed species such as Black pigweed (Trianthema portulacastrum), Hariyali (Cynodon dactylon), Parthenium (Parthenium hysterophorus), Euphorbia, (Euphorbia peplus), and Sage bud (Pectis glaucescens), Dudhi (Euphorbia hirta), Kunda-smooth crabgrass (Digitaria ischaemum), Aghada (Achyranthus aspara), Kena (Commelina benghalensis), Horseweed (Erigeron canadensis), Nut grass (Cyperus rotundus).

Beneficial Insect Incidence

- Both districts reported the presence of beneficial insects throughout different growth stages.
- Ladybird beetles (*Coccinellidae*) were predominant in Dhule, while Chrysoperla (*Chrysoperla carnea*) dominated in later stages. Nandurbar observed Ladybird beetles, Chrysoperla, Praying mantids (*Mantodea*), dragonflies (*Anisoptera*), and Syrphid flies (*Syrphidae*).
- In the Nandurbar region, a greater diversity of beneficial insects is observed, attributed to the comparatively lower application of chemical pesticides and reduced use of highly hazardous pesticides compared to the Dhule district.

Discussion

The findings from both districts underline the multifaceted challenges in cotton cultivation, including pest and disease pressures, weed competition, and the delicate balance of beneficial insects. Integrated pest management strategies must be tailored to address these challenges while minimizing environmental impacts. Timely interventions, cultural practices, and the utilization of biopesticides play critical roles in managing pest and disease outbreaks. Furthermore, effective weed management practices are essential to mitigate weed competition and ensure optimal crop yields.

The presence of beneficial insects highlights the potential for natural pest control mechanisms, emphasizing the importance of biodiversity conservation in agricultural landscapes. Collaboration among stakeholders is crucial for developing and implementing sustainable pest management practices tailored to the specific agroecological conditions of each district.

Biopesticide Efficacy Results

The studies conducted in the Dhule and Nandurbar districts aimed to evaluate the efficacy of biopesticides in controlling pests and diseases affecting cotton crops. Observations before and after biopesticide applications provided insights into the percentage reduction of pest infestations and the health of beneficial insect populations.

Across both districts, biopesticides such as Neemark, Verticillium, Beauveria, and Trichoderma showed substantial efficacy in reducing infestations of sucking pests, pink bollworm, and wilt disease. In Dhule, the reduction in sucking pests was notable with Neemark and Verticillium, whereas Beauveria and Trichoderma targeted pink bollworm and wilt effectively. Similarly, Nandurbar district results reflected effective pest management with these biopesticides, demonstrating their potential as sustainable alternatives to chemical treatments.

Table 1: Mean Comparison of (%) Infestation and (%) Infestation reduction of pests and diseases of Biopesticides after 7 to 10 Days (Dhule district)

Treatment	For Which Pest	Pre-Treatment	Post-Treatment
Neemark	Sucking Pest	35.583 (0.524)*	21.000 (0.780)*
Verticillium	Sucking Pest	43.333 (1.009)*	16.583 (0.448)*
Beauveria	Pink Bollworm	38.417 (0.852)*	16.167 (0.245)*
Trichoderma	Wilt	18.667 (1.228)*	5.583

*(Figures in parenthesis are square root x+0.5 transformed values for numbers)

Table 2: Mean Comparison of (%) Infestation and (%) Infestation reduction of pests and diseases of Biopesticides after 7 to 10 Days (Nandurbar District)

Treatment	For Which Pest	Pre-Treatment	Post-Treatment
Neemark	Sucking Pest	42.833 (6.550)*	24.5 (5.000)*
Verticillium	Sucking Pest	48.25 (6.941)*	18.833 (4.359)*
Beauveria	Pink Bollworm	32.667 (5.715)*	12.833 (3.605)*
Trichoderma	Wilt	27.333 (5.230)*	10.417 (3.234)*

*(Figures in parenthesis are square root x+0.5 transformed values for numbers)

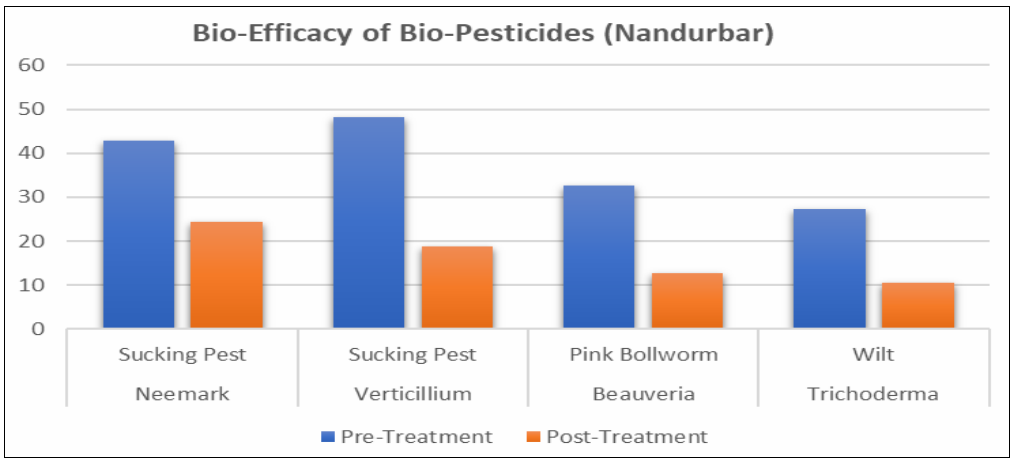

Fig 1: Percentage reduction of severity in Dhule district

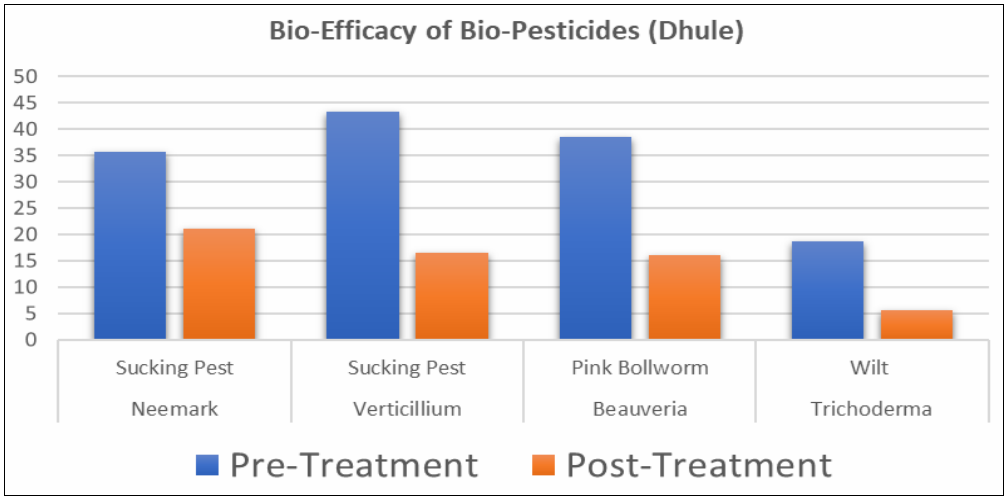

Fig 2: Percentage reduction of severity in Nandurbar district

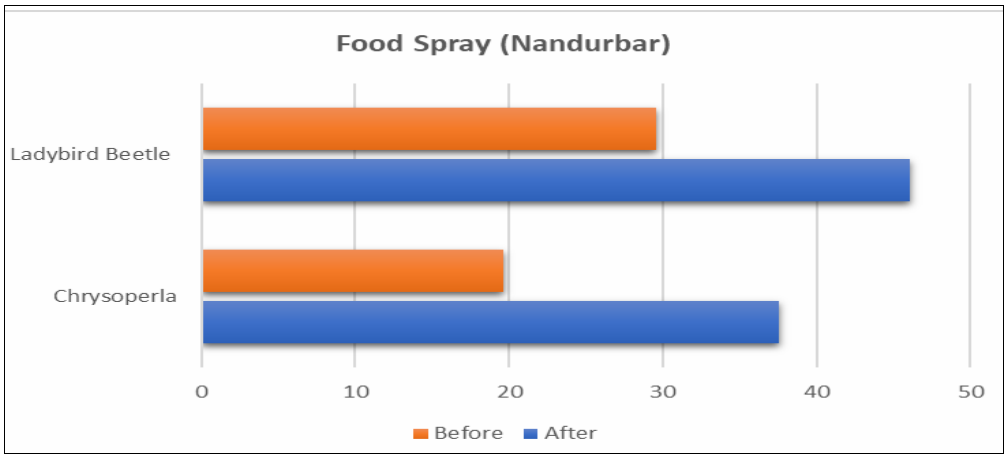

Fig 3: Observations on the percentage increase of beneficial insects following the application of food spray in the Dhule District."

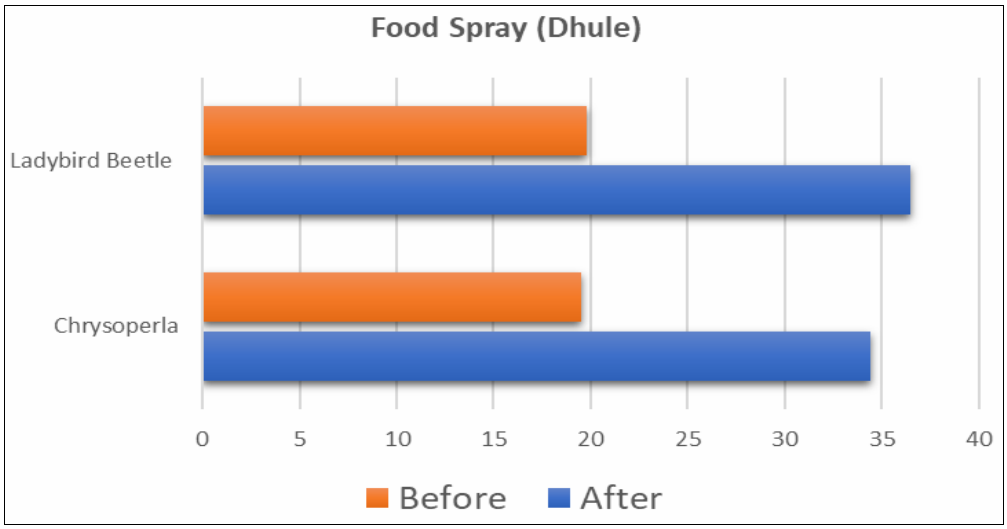

Fig 4: Observations on the percentage increase of beneficial insects following the application of food spray in the Dhule District.

Food Spray Impact on Beneficial Insects

The application of food spray significantly improved the populations of beneficial insects in both districts. In Dhule, Chrysoperla and Ladybird Beetle populations increased post-application, indicating a healthier crop environment conducive to natural pest suppression. Nandurbar district observed similar trends, with increases in Chrysoperla and Ladybird Beetle populations, highlighting the positive outcomes of integrating biocontrol agents and practices in pest management strategies.

Table 3: Changes in Beneficial Insect Populations before and After Food Spray Application (Dhule)

Beneficial Insect	Before food spray	After food spray
Chrysoperla	19.5%	34.42%
Ladybird Beetle	19.83%	36.5%

Table 4: Changes in Beneficial Insect Populations before and After Food Spray Application (Nandurbar)

Beneficial Insect	Before food spray	After food spray
Chrysoperla	19.66%	37.58%
Ladybird Beetle	29.58%	46.08%

Discussion

The findings from both districts underscore the effectiveness of biopesticides in sustainable agriculture, showcasing significant pest and disease control while supporting beneficial insect populations. The reduction in pest infestations and the enhancement of natural pest control mechanisms through increased beneficial insect populations indicate a promising direction for integrated pest management (IPM) strategies.

Moreover, the observed efficacy of biopesticides in targeting specific pests without adversely affecting non-target species emphasizes the importance of selecting appropriate biocontrol agents. This approach aligns with the goals of sustainable agriculture by reducing chemical inputs, minimizing environmental impact, and promoting biodiversity.

Future research directions should focus on the long-term sustainability of biopesticide use, potential resistance development, and the integration of these biocontrol methods within broader IPM programs. The positive outcomes observed highlight the need for continued exploration and adoption of biological control methods in agriculture to ensure sustainable and environmentally friendly pest management solutions.

Acknowledgment

"Lupin Human Welfare & Research Foundation (LHWRF) is the social responsibility arm of Lupin Limited, founded by Dr. Desh Bandu Gupta in 1988. In its journey spanning over three decades, the foundation has covered over 1.45 million beneficiaries in over 5000 villages in 23 districts spread across nine states in India. Over the years, the foundation has largely focused on building sustainable livelihood opportunities and triggering economic growth in some of the most backward and underdeveloped districts of India. It has adopted a family-centered approach and initiated measures that help them break the vicious circle of poverty, positively impacting their lives and livelihoods. To ensure that economic development is substantiated by social upliftment and an improvement in quality of life, the organization has been working relentlessly in the areas of health and education at the grassroots level. Structured efforts have been made to upgrade the local infrastructure, build awareness, catalyze positive behavior change, and facilitate access to healthcare services for the most marginalized and underserved communities. The foundation works extensively with various government and non-government partners, international development agencies, and like-minded philanthropic organizations to mobilize additional resources and extend its reach to several more isolated and underserved populations, covering a large majority of landless tribal, scheduled caste, and minority populations in target geographies. As one of the parts of the organization's livelihood strategies Better Cotton Initiative is the major project where 95156 smallholder farmers are engaged in sustainable cotton production."

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