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Research Article

Prospects and challenges of biopesticide use in Nepal

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ABSTRACT: Agriculture contributes approximately 24.1% to GDP and employs 64.8% of the population in Nepal. To prevent an estimated 35% crop loss due to insect pests and diseases, farmers generally depend on agrochemicals. The chemical pesticides pose challenges like residues, insecticide resistance, resurgence, bio-magnification, besides, improper handling, storage, and disposal of pesticides. The harmful impacts of conventional pesticide use have become more evident, particularly through recent increases in chronic health issues linked to exposure. In this context, the use of biopesticides in Nepal presents a promising alternative to conventional chemical pesticides, aligning with sustainable agricultural practices, safety to users, and environmental protection. The study explores the status, challenges, and prospects of biopesticide use in Nepal. This employs a literature review, a questionnaire-based survey with agro-advisory service providers, and data analysis from the Plantwise Online Management System (POMS) to assess the awareness, adoption, and challenges of biopesticide use in Nepal. Findings reveal that biopesticides account for only 0.015% of total pesticide imports in Nepal. Key challenges to their adoption include limited availability, the perception of lower efficacy compared to chemical pesticides, higher costs, and a lack of training on proper application and dosage. The study highlights the importance of increased awareness, robust regulatory frameworks, and collaborative efforts among government agencies, research institutions, private sector stakeholders, and farmer organisations to promote the effective use of biopesticides. Addressing these challenges through capacity-building initiatives and supportive policies is crucial for the successful integration of biopesticides into Nepalese agriculture.

Keywords: Biopesticides, challenges, Nepal, POMS

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INTRODUCTION

Agriculture plays a pivotal role in Nepal's economy, contributing approximately 24.1% to the national GDP and providing employment to 64.8% of the population (MoALD, 2023). The adoption of improved crop varieties, particularly vegetables, has gained significant traction among farmers. However, crop losses due to insect pests and diseases are estimated at 35% (Oerke, 2005). To mitigate these losses, conventional pesticides have become the predominant solution, especially in commercial vegetable production zones, where pesticide use averages around 1600 g/ha, far exceeding the national average of 396 g/ha (PRMD, 2014). While effective in the short term, the overuse of chemical pesticides raises serious concerns, including health risks, ecological degradation, and the development of pesticide resistance. There are several environmental exposure pathways related to pesticides, such as excessive and indiscriminate use, and the improper disposal of pesticides and empty containers (Pimentel, 2005; Aktar *et al.*, 2009). Unsafe use of chemical pesticides has led to multiple issues, including pest resistance, pest resurgence, pesticide residues in food, water, air, and soil, loss of natural enemies, and disruption of ecosystems (Palikhe, 2002). Recognising these challenges, the Government of Nepal (GoN) has prioritised Integrated Pest Management (IPM) as a key pest control strategy. Following the outbreak of the Brown Plant Hopper (*Nilaparvata lugens* Stal) in rice crops in Chitwan district in 1997, various government bodies, NGOs, and development partners implemented an IPM pilot program under the FAO-TCP program in 1998 (G C, 2012; Kafle *et al.*, 2014; PPD Nepal, 2009).

Despite having diverse climatic and geographical conditions, Nepal has heavily relied on agriculture for livelihoods and food security, and continues to face several challenges in adopting biopesticides. Biopesticides are derived from natural sources such as plants, animals, or microorganisms, and offer a more sustainable and environmentally friendly alternative to conventional

chemical pesticides (Copping, 2009). According to the EPA (2023), biopesticides include a variety of products derived from natural substances such as bacteria, fungi, plants, and certain minerals. However, the production and effective use of biopesticides in Nepal is being hindered by various factors such as limited awareness and know-how, availability and access, efficacy and performance, cost and affordability, technical expertise and training, as well as the regulatory framework. The regulatory framework for biopesticides in Nepal may not be well-defined or adequately enforced. Clear guidelines and regulations, along with a robust monitoring and enforcement system, are necessary to ensure the quality, safety, and efficacy of biopesticides in the market. Addressing these challenges requires coordinated efforts among government agencies, research institutions, extension services, private sector stakeholders, and farmer organisations. There is a great scope for the integration of biopesticides with conventional practices of insect pest and disease management. To overcome different biotic and abiotic problems of crops, Nepal can also choose natural farming and rely on the usage of bio-rational substances such as biopesticides (G C, 2015). This manuscript highlights the current status, challenges, and opportunities for the wider adoption of biopesticides in Nepalese agriculture.

MATERIALS AND METHODS

In present study, a comprehensive approach was adopted to collect relevant information. A thorough literature review was conducted to analyse the existing status of biopesticide use in Nepal. Additionally, secondary data were systematically gathered from published sources, institutional reports, and relevant agricultural databases.

To complement this information, a structured questionnaire was administered to 78 agro-advisory service providers across Nepal in January–February 2024 to gauge their perceptions of biopesticide use. Respondents' perceptions of the challenges associated with biopesticide use were analysed using a five-point scale of constraints, where 1 represented the lowest level of constraint and 5 the highest. An Index of Importance was calculated using the following formula:

$$I_{imp} = å (Si\ F_i /N)$$

where,
I_{imp} = Index of importance
å = Summation
Si = Scale value
F_i = Frequency of importance given by the respondents
N = Total number of respondents

Furthermore, data from CABI's Plantwise Online Management System (POMS) were analysed to assess the extent of biopesticide recommendations made by plant doctors during plant clinic sessions. POMS is a data management tool to store, manage, and analyse the plant clinic data. Data from 6,636 plant clinic records from 2013 to 2022 were analysed to assess trends in biopesticide recommendations.

This methodological approach ensured both qualitative and quantitative insights into the current practices and perceived barriers to biopesticide use in Nepal.

RESULTS AND DISCUSSION

Pesticide use in Nepal

Pesticide use in Nepal has been increasing at an annual rate of 10 to 20%. While the national average pesticide consumption is around 396 g/ha, usage in commercial vegetable production zones is significantly higher, reaching up to 1600 g/ha (PRMD, 2014). The volume of pesticide imports has also seen a sharp rise, increasing from 454.6 metric tonnes (mt) in 2013/14 to 1135.5 mt in 2021/22, and further to 1183.7 mt in 2022/23 (PQPMC, 2023, 2024) (Figure 1).

Despite this growing trend, the share of biopesticides remains extremely low, accounting for only 0.015% of the total pesticide imports (PQPMC, 2023) (Figure 2).

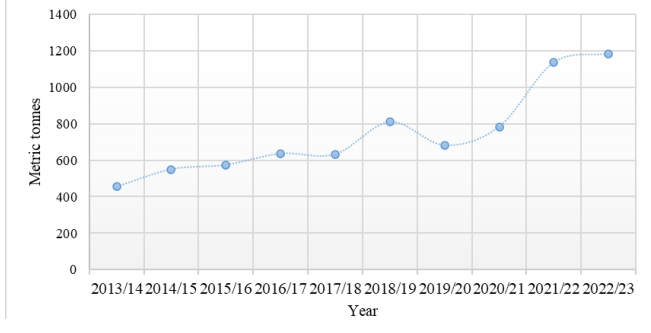


Figure 1. The pesticide import (a.i.) in Nepal. Source: (PQPMC, 2024)

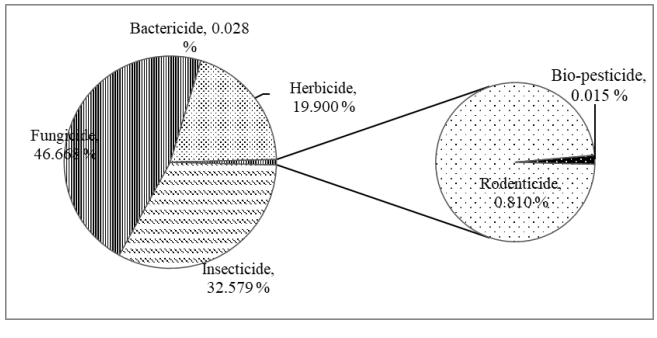


Figure 2. Share of different pesticides in Nepal**.** Source: (PQPMC, 2023)

A total of 15 biopesticides were registered in Nepal by 2024 (14 biopesticides in 2023) (Table 1) (PQPMC, 2024). However, a study conducted by Kafle *et al.* (2021) on the pesticide usage by Chitwan farmers shows 84% of farmers (663 farmers) exclusively used chemical pesticides, while only 3.5% (28 farmers) farmers used botanical biopesticides (Table 2). This shows farmers heavily using chemical pesticides for managing their pests and diseases.

Findings from the agro-advisory service providers survey

The results from the agro-advisory service providers survey showed that only 36% (n = 28) of the respondents are highly aware of the biopesticides, whereas 62% (n = 48) of the respondents are moderately aware. The majority of the respondents rely on research articles, government officials, and training programs to get the source of information on biopesticides (Figure 3).

Among the biopesticides registered in Nepal, most respondents, the agro-advisory service providers from government offices, are familiar with biopesticides like Azadirachtin (82%), *Trichoderma viride* (79%),

Table 1. Registered biopesticides in Nepal

S. No.	Common name
1	*Azadirachtin*
2	*Bacillis amyloloquefaciens D 203*
3	*Bacillus subtilis*
4	*Bacillus thuringiensis*
5	*Beauveria bassiana*
6	*Heterorhabditis indica*
7	*Metarhizium anisopliae*
8	*Nuclear Polyhedrosis Virus*
9	*Paecilomyces lilacinus*
10	*Phthorima operculella Granulovirus isolates*
11	*Pseudomonas fluorescens*
12	*Trichoderma harzianum*
13	*Trichoderma viride*
14	*Verticillium chlamydosporium*
15	*Verticillium lecanii*

Source: (PQPMC, 2024)

Table 2. Pesticide use by the farmers in Chitwan

S. No.	Pesticides	Percentage
1	Exclusively using chemical pesticides	84.0
2	Using botanicals only	3.5
3	Using both botanicals and chemical pesticides	12.5

Source: (Kafle *et al.*, 2021)

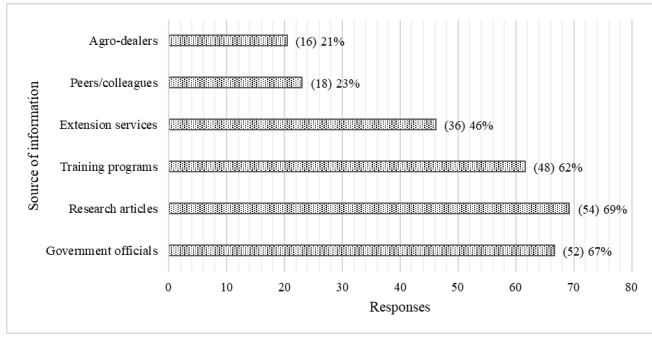


Figure 3. Source of information on biopesticides.

Bacillus thuringiensis (77%), *Metarhizium anisopliae* (74%), *Verticillium lecanii* (74%), and *Beauveria bassiana* (72%). When we asked respondents, Have you ever recommended biopesticides in your recommendations to manage agricultural pests? 87% (n=68) of them have responded 'Yes'. However, most of the agro-advisory service providers' recommendations include only Azadirachtin (79%), followed by *Trichoderma viridae* (64%) and *Bacillus thuringiensis* (51%). These figures also support the commonly used biopesticides by farmers in Nepal. The respondents mentioned that Azadirachtin (77%) and *Trichoderma viridae* (59%) are the commonly used biopesticides by farmers (Figure 4). The data reveal that across nearly all biopesticides, knowledge among agro-advisory providers is significantly higher than both recommendation and usage rates by farmers. Except for Azadirachtin and *Trichoderma viridae,* the awareness level to recommendation rate and usage by farmers is significantly low. This data underscores a critical "knowledge-to-practice gap" in Nepal's biopesticide ecosystem. While agro-advisory providers are aware of various biopesticides, recommendation rates are low, and actual farmer adoption remains minimal. This suggests several barriers, including availability, cost, awareness issues, doubts about efficacy, lack of training on application methods, *etc*.

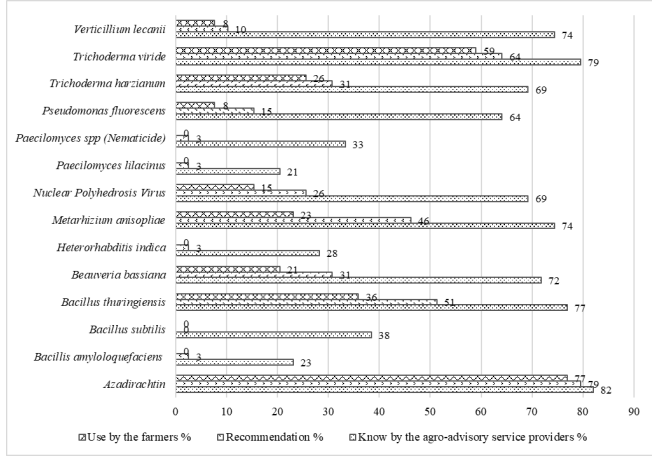


Figure 4. Biopesticides known (by respondents), their recommendations, and use in Nepal.

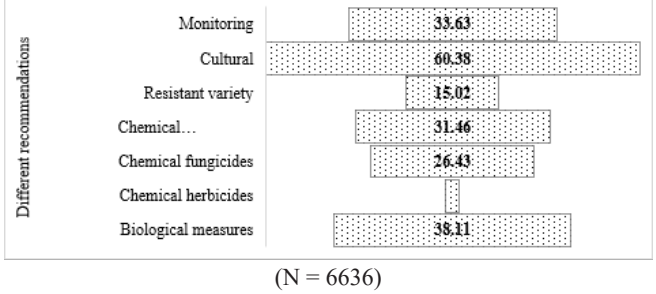
Recommendation of biological measures in plant clinics

An analysis of recommendations from plant clinic sessions across Nepal from 2013 to 2022 reveals a positive trend in the promotion of non-chemical pest management approaches. Data shows that among various management options recommended by plant doctors, biological measures were recommended in 38.11% of the cases, while cultural practices were recommended in 60.38%. The chemical recommendations include 31.46% of insecticides/acaricides, 26.43% of fungicides, and 2.28% of herbicides (Figure 5). This reflects a growing awareness and confidence among plant doctors in recommending safer, environment-friendly alternatives such as biopesticides.

Challenges of biopesticide use

The majority of the agro-advisory service providers who were interviewed in the study (87%) recommended biological practices for pest management. Similarly, 38.11% of the recommendations prescribed by plant doctors in the plant clinic sessions contain biological measures. Despite this, there are key challenges associated with the adoption and use of biopesticides in Nepal. Table 3 presents the key challenges perceived by respondents. These challenges encompass various technical, economic, regulatory, and awareness-related constraints that hinder the widespread adoption of biopesticides in agricultural pest management.

The challenges reported were the perceived lower efficacy of biopesticides (Rank I), followed by limited market availability (Rank II). Other concerns include a lack of awareness, high costs, and limited technical support for proper usage. Though the perceived lower efficacy compared to chemical pesticides ranked first, it is a general perception among the farming community that they expect quick results. However, biopesticides generally take a longer time to show results compared to chemical pesticides. One of the other most significant challenges reported is the limited availability and accessibility of biopesticides, indicating that farmers often struggle to procure biopesticides due to inadequate market supply and distribution networks. Additionally, high



(N = 6636)

Figure 5. Recommendation of different management measures in the plant clinic sessions in Nepal.

Table 3. Challenges of biopesticides use perceived by the respondents

S. No.	Challenges	Perception index value	Rank
1	Lack of awareness about biopesticides	2.86	III
2	Limited availability of biopesticides in the market	3.29	II
3	Insufficient training on biopesticide application and dosage	2.55	IV
4	Perceived lower efficacy compared to chemical pesticides	3.32	I
5	High cost of biopesticides	2.51	V

cost and low affordability were highlighted as economic constraints, suggesting that many farmers find biopesticides more expensive than conventional chemical pesticides, which discourages their use. Another major issue identified is a lack of awareness and technical knowledge among farmers, implying that insufficient training and extension services limit farmers' confidence in using biopesticides effectively.

Regulatory challenges, such as weak policy support and a lack of quality assurance mechanisms, were also perceived as challenges for the adoption and use of biopesticides. The absence of stringent regulations for biopesticide production, registration, and standardisation leads to variability in product quality and effectiveness, further reducing farmers' trust. Additionally, limited research and extension support were cited as factors impeding the development and adoption of biopesticides. Overall, these results underscore the need for policy interventions, enhanced research, improved farmer education, and a well-established supply chain to promote biopesticide adoption as a sustainable alternative to chemical pest control.

Stakeholders in biopesticide management and promotion in Nepal

Biopesticides play a crucial role in integrated pest management (IPM) and sustainable agricultural practices. The successful promotion and adoption of biopesticides involves coordinated efforts among multiple stakeholders: government, research institutions, private sector, development partners, and farmers.

Governmental institutions

(i) *Ministry of Agriculture and Livestock Development (MoALD)*: The primary regulatory body overseeing national policies and strategies for sustainable pest management, including biopesticide promotion.

(ii) *Plant Quarantine and Pesticide Management Centre (PQPMC)*: Responsible for registration, regulation, and monitoring of biopesticides in Nepal.
(iii) *Department of Agriculture (DoA)*: Implements biopesticide-related programs and provides extension services to farmers.
(iv) *Central Agricultural Laboratory (CAL)*: Conducts plant pest diagnostic service and recommends biopesticide products for management.
(v) *Provincial-Level Plant Protection Laboratories*: Facilitate biopesticide research, production, and technical support at the provincial level.
(vi) *Agriculture Knowledge Centres/District Agriculture Development Offices*: Serve as extension hubs for biopesticide adoption and farmer outreach.
(vii) *Local Level Agricultural Sections*: Play a vital role in implementing biopesticide policies at the local and community levels.
(viii) *Projects such as: Prime Minister Agriculture Modernisation Project (PMAMP), Agriculture Sector Development Programme (ASDP), and Food and Nutrition Security Enhancement Project (FANSEP)*: Support the adoption of biopesticides under its pocket, block, and super/zone initiatives. Promotes sustainable agriculture practices, including biopesticide use. Integrates biopesticides into climate-smart agricultural interventions.

Research and academic institutions

(i) *Nepal Agricultural Research Council (NARC)*: Conducts research on biopesticides, pest dynamics, and their integration into IPM strategies.
  – National Entomology Research Centre (NERC)
  – National Plant Pathology Research Centre (NPPRC)
(ii) *Universities and Academia*: Engage in research, development, and capacity-building for biopesticides.

Development partners (I/NGOs)

(i) *Food and Agriculture Organisation (FAO)*: Supports policy development and technical training for biopesticide adoption.
(ii) *CABI (CAB International)*: Provides expertise on biological control agents and biopesticide management.
(iii) *iDE Nepal, Caritas, Heifer International, World Education*: Promote biopesticides through IPM FFS and sustainable agriculture projects.
(iv) *Local Organisations and Farmer Networks*: Organisations such as the Plant Protection Society of Nepal (PPSN), TITAN, and Nepal Public Health Foundation (NPHF) play an advocacy and implementation role in biopesticide dissemination.

Private sector and community-based initiatives

(i) *Biopesticide Producers*: Local and international companies involved in the formulation and distribution of biopesticides.
(ii) *Pesticide Entrepreneurs' Association Nepal (PEAN)*: Represents private sector stakeholders engaged in biopesticide manufacturing and trade.
(iii) *Community IPM Resource Centres*: Serve as local hubs for knowledge dissemination and farmer training in biopesticide application.

By fostering collaboration among these stakeholders, Nepal aims to promote environmentally friendly pest management solutions, enhance agricultural productivity, and ensure food security through biopesticide adoption.

CONCLUSIONS

Biopesticides offer an environmentally sustainable and effective alternative to conventional chemical pesticides, aligning with Nepal's commitment to protect ecosystems and promote sustainable farming practices. Despite their potential, the widespread adoption of biopesticides in Nepal faces several critical challenges. These include limited awareness and technical knowledge among farmers, insufficient access to reliable and high-quality biopesticide products, and a lack of comprehensive capacity-building programs. To overcome these barriers, it is essential to invest in targeted technical support, robust training initiatives, and financial mechanisms that facilitate the use of biopesticides. Enhancing farmers' understanding and application of these alternatives requires coordinated efforts among key stakeholders, including farmers, government agencies, Non-Governmental Organisations (NGOs), research institutions, and the private sector. Developing supportive policies, regulatory frameworks, and incentive structures will be vital for mainstreaming the use of biopesticides. A collaborative, multi-sectoral approach can ensure not only the successful implementation of biopesticides but also long-term improvements in agricultural sustainability and ecosystem health in Nepal.

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