PROMOTION OF BIOPESTICIDES FOR SAFER FOOD PRODUCTION AND PROTECTION OF ENVIRONMENT

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ABSTRACT

Pesticides are used for pest control in agriculture, external parasite control in animals and vector control in public health. Use of Synthetic pesticides in the globe is increasing due to emerging new pests in the contest of changing climate, quick knockdown effects and use of high yielding varieties in agriculture commercialization to fulfill the demand of food and nutrition of growing population. But the use of pesticides has negative effects on health of human and environment due to lack of awareness, negligence, improper guidance on the problem, and improper handling of pesticide. Biopesticides specially neem-based insecticides, insect specific pheromones, light traps, yellow traps, repellents, *Trichoderma, Pseudomonas, Bacillus*, NPV and nematodes have been registered and their uses are increasing due to safety, effectiveness and as the best alternatives of chemical synthetic pesticides. Government should to encourage in registration process of biopesticides facilitating by guidelines within the regulatory frame while maintaining their quality, awareness and advocacy for their promotion in the nation.

Key words : Synthetic pesticides, biopesticides, international agreement, pesticide act, public health

INTRODUCTION

The world's population could grow to around 8.5 billion in 2030, 9.7 billion in 2050, and reaching a peak of around 10.4 billion people during the 2080 (UN, 2022) and total global food demand is expected to increase by 35% to 56% between 2010 and 2050 (Alexandratos and Bruinsma, 2012). FAO estimates that global cereal production will need to increase by almost 1 billion tons by 2050.

About 20-40% of global crop production is lost due to plant pests and diseases specially insects, fungi and bacteria (FAO, 2022). Unlike synthetic pesticides, which can degrade soil health and disrupt ecosystems, biopesticides often have beneficial effects on soil fertility and biodiversity. This promotes long-term soil and environmental health (Pretty, 2008).

Due to climate change, each additional degree of temperature rise could cause global yield losses from insect pests to increase by a further 10-25%, the results suggest (Deutsch et al. 2018). To protect the crops from the pests, farmers preferred the pesticides with quick knock down effect. But pesticides have a lot of negative consequences in the human health and environment due to their overuse, misuse, no use of personal protective measures and improper disposal of the containers.

Currently, around two million tons of pesticides are used per year on a global basis, most of which are herbicides (50%), followed by insecticides (30%), fungicides (18%) and other types such as rodenticides and nematicides (Sharma et al., 2019). Developing countries use approximately 25% of the world's pesticides, whereas deaths linked to pesticides found 99% (WHO, 2008). Every year, 385 million people (44% of the world's farming population) are poisoned in the course of their work, with an estimated 11,000 people sadly losing their lives. Even more significantly, more than 100,000 people die yearly from intentional (self-harm) poisoning with pesticides (Roger, 2024). Pesticide poisoning is one of the most common methods of suicide worldwide, responsible for at least 14 million deaths since the 1960s. Pesticides can be up to ten times more toxic for children than for adults, and the impact of pesticide exposure can include birth defects, cancer, neurological development issues and hormonal issues (Roberts et al., 2012). These data show that the persons who handle the pesticides and are indirectly exposed and contaminated may show chronic toxicity. On other hand, the production of pesticides emits on average much more greenhouse gas (GHG) (at least once its full form) per kg (6.3 kg CO_2 kg^{-1}) than the production of synthetic nitrogen-fertilizers (1.3 kg CO_2 kg^{-1}), which is known to be very energy intensive (Lal, 2004). Therefore, by reducing the use of synthetic pesticides, biopesticides help mitigate the risks associated with chemical exposure for farmers, farmworkers, and consumers. This is particularly significant in regions where pesticide-related health issues are prevalent (Jeyaratnam, 1990).

Biopesticides harness naturally occurring compounds and organisms to control pests, aligning with the principles of nature-based solutions for sustainable development. This approach emphasizes working with nature rather than against it (Diaz et al., 2015). With increasing consumer demand for organic and sustainably produced food, biopesticides play a crucial role in ensuring safe food production by minimizing chemical residues (Oerke, 2006).

For proper management of the pesticide business within the country, the Government of Nepal has enacted the Pesticides Management Act, 2019 and Pesticides Management Regulation 2024. The Act has the provisions of product registration, licensing, qualification of the importer, reseller, pesticide formulator or producer, applicator, packaging and repackaging of the product. Similarly, re-registration, suspension of registration, renewal, revoke of license, formation of the pesticide management committee, pesticides to be restricted or banned, production of domestic pesticides, promotion of biopesticides, appointment of pesticide inspector for the management of the pesticide in the district, offence, punishment and compensation management of date expired pesticides are the major provisions in the act.

MATERIALS AND METHODS

For this study the provisions in the Pesticide Management Act, 2016 and Pesticide Management Regulation, 2024 were thoroughly reviewed. Minutely studied the provisions including the registration process, suspended registration, re-registration of the pesticides, renewal of the pesticides, provisions related licenses, license revoked, licenses to be obtained in the province, provision of pesticide management committee, registration and management center, use and management of pesticides, use of domestic pesticides, production and use of botanical pesticides to be encouraged, use of pesticides to be restricted, management of the date expired pesticides, provision of inspector appointment, establishment of laboratory for quality testing of pesticides, disposal of pesticides, offence, punishment and compensation, provincial pesticide management

committee, and monitoring of the pesticide activities within the country. Some gaps on pesticide management and sustainable safe food production were also identified.

Similarly, Periodic Plans, Agriculture Development Strategy, policy papers, annual report of Ministry of Agriculture and Livestock Development, publications of Plant Quarantine and Pesticide Management Centre (PQPMC) among others were reviewed and focused on relevant areas. Nepal, being the signatory of Basel, Rotterdam and Stockholm Convention, World Trade Organization Food and Agriculture Organization of the United Nations and World Health Organization, is guided technically by their decisions, documents and our rules and regulations for pesticide management need to be synchronized. These documents were reviewed to assess the gap for addressing the safety with no adverse effects on health of human, animal, plant and ecosystems and use of climate smart crop protection.

RESULTS AND DISCUSSION

Emerging issues due to use of synthetic pesticide:

Plants are fulfilling 80% of our daily calories and 98% of the required oxygen for breathing. Annually 20-40% global crop production is lost due to plant pests, and diseases and losses at least 24% by invasive insects (FAO, 2022). The global population is expected to reach 8.6 billion in 2030, 9.8 billion in 2050 and 10.4 billion in 2100 (UN, 2022) and based on this purposed increment in world human population need to increase the amount of food by 14060 trillion crop calories in 2050 which is 47% of increment in crop calories from a baseline 2011 (USDA, 2017). Production and use of pesticides and fertilizers globally have increasing due to increasing demand of food (Oliver, 2018; FAO, 2021; IFA, 2021) and the similar trend can be seen in Nepal (PQPMC, 2023). Global use of pesticide is 3.54 million tons per year in 2021 (FAOSTAT, 2024). More than 1000 pesticides by common name are used to ensure food destroyed by pests in the world (WHO, 2024).

Pesticide products are classified according to their chemical composition and include an ample diversity of conventional pesticides, herbicides, insecticides, rodenticides, plant growth regulators, miticides, nematicides, fungicides, fumigants, and antimicrobial agents (EPA 2020). Pesticides are essential to increase agricultural productivity, but can have highly deleterious impacts on the environment, biodiversity, and, in particular, public health (Gil and Pla 2001; Parker et al., 2017; Vale et al., 2019; Sharma et al., 2020; Ramos et al., 2021). Lots of acute and long-term human health and environment related impacts are being observed due to exposure of pesticides (Prüss-Ustün et al., 2016; Ntzani et al., 2020). An increase in the number of leukemia cases has been recorded in children of under 5 years of age, which was not linked to any maternal or intrauterine exposure to pesticides, but rather to perinatal exposure to the contaminated father (Salerno et al., 2016; Gunier et al., 2017; Jackson et al., 2017).

Plant Quarantine and Pesticide Management Center (PQPMC) is the responsible organization for execution of the pesticide management act and regulation in the country which can give priority to register the safe categories of pesticides. The act has the provisions for encouraging the production and use of biological pesticides and domestic pesticides.

Impact of pesticide on pollination and suicide:

Pesticides impacts have been observed in bees and other pollinators, natural enemies of pests, bird population, aquatic organisms, and biodiversity (Cloyd 2012; Roubos et al., 2014; Kovács-Hostyánszki et al. 2016; Sánchez-Bayo and Wyckhuys 2019; Tassin de et al., 2020).

Pesticide is one of the most common methods of suicide and 14 million people died since 1960, and 20% of global suicide is due to pesticides poisoning from rural farm communities and cause of high toxicity, sold locally and store at home (CPSP, 2023). About 385 million cases of pesticide poisoning occur worldwide every year (Pesticide atlas, 2022). In Nepal, 5754 suicide cases were recorded in 2018-2019 where 24% of the suicide cases were by poisoning due to ingestion of highly concentrated agricultural pesticides (Utyasheva et al. 2021). Therefore, for reduction of poisoning cases due to pesticides, Nepal has banned those highly hazardous pesticides. Conventional and old generation pesticide should be phase out and encourage to registered and the use of safe and new generation pesticides. In different time period, Nepal has banned highly hazardous 25 common pesticides considering to human health and environment protection (PQPMC, 2024).

List of Banned Pesticides in Nepal

1. Aldrin
2. BHC
3. Chlordane
4. Dieldrin
5. DDT
6. Endrin
7. Methyl parathion
8. Lindane
9. Organo Mercury Fungicide
10. Carbosulfan
11. Toxaphene
12. Heptachlor
13. Carbaryl
14. Dicofol
15. Phosphamidon
16. Benomyl
17. Endosulfan
18. Phorate
19. Carbofuran
20. Dichlorvus
21. Monocrotophos
22. Mirex
23. Chlorpyriphos
24. Trizophos
25. Paraquat/Paraquat dichlor
26. Aluminum Phosphide
    (3-gram tablet)

When 56% Aluminum Phosphide 3-gram tablet banned in Nepal, the suicide cases due to pesticide poisoning found to be reduced by 20-30% (CPSP, 2023).

Pesticide residues in food: Pesticides while sprayed in the field goes to the soil, degrades the soil, water bodies and float in the air also (Rani et al., 2021) and some quantity of pesticide residue comes in the food. A study in Nepal showed that 93% eggplant and 100% tomato and chilli samples found pesticide residues, where 4% eggplant, 19% chilli and 40% tomato samples exceeded European Union maximum residue limits (MRLs) (Bhattarai et al. 2019). Pesticide residues are harmful to health and Codex Alimentarius Commission has developed the standard of MRL of pesticides in different types of food commodities and MRL of pesticide in food vary from country to country. Department of Food Technology and Quality Control (DFTQC) of government of Nepal is the responsible organization for decision of MRL of pesticides in food and has set the MRLs of some foods, vegetables and fruits.

Greenhouse gas emission due to pesticides: Temperature may increase the selection pressure to resistance alleles in the pests and result in more pesticide application (Delcour et al., 2015). Scientific evidence indicates that pesticides contribute significantly to greenhouse gas emissions and also making agricultural systems more vulnerable to the effects of climate change (EPA, 2022). The production of synthetic pesticides is energy intensive and can emit even more Green House Gas (GHG) per kg than the production of synthetic fertilizers (Rosa and Gabrielli, 2023).

Nitrogen fertilizers and pesticides release GHG emissions after application, with some pesticides shown to increase nitrous oxide production in soils (Muhle, 2009). Some pesticides, such as sulfuryl fluoride, are themselves powerful GHGs, having nearly 5000 times the potency of carbon dioxide (Spokas and Wang, 2003). Therefore, the provision of the pesticide management act to discourage chemical pesticide production and encourage for biological and domestic pesticide production and use is promising.

Consumption of pesticide and its risk:

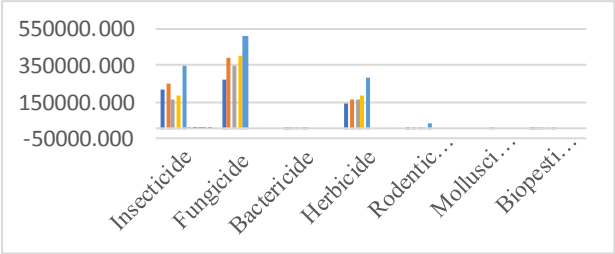


Fig. 1. Pesticide imports and consumption

Source: PQPMC, 2023

The average national consumption of pesticide in Nepal is 396 g a.i. per ha but pesticide used in vegetables is higher (1.604 kg) followed by cash crops (0.1865) and cereals (0.04613) (PPD, 2016; Sharma, 2015) which seems low as compared to other countries.

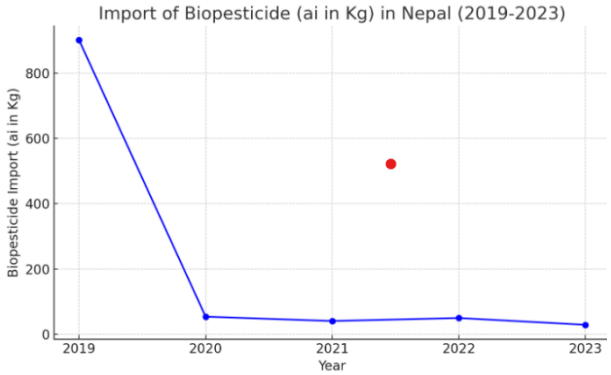


Fig. 2. Import of biopesticide in Nepal.

Source: PQPMC, 2023

The average consumption per unit area is low but the risk due to pesticide is high because farmers, shopkeepers and other persons who expose to pesticide and such risks are associated with lack of awareness during selection of pesticide, mixing, use, waiting period for harvesting of the product, disposal

of containers and use of personal protective measures. Due to misuse, over and underuse of pesticides arise a lot of mutagenic and carcinogenic diseases, birth defects, abnormalities in children, reduced fertility rate in human, resurgence of new pests, pesticide resistance in insects and pathogens, reduced load of beneficial microbes in the soil, contamination of water source and rivers, bio-magnification of pesticide in food chain, impact on production, wild lives and biodiversity.

In Nepal, the consumption of pesticide is increasing from 454.59 metric ton active ingredient (a.i.) in 2013-14 to 1135.50 metric ton a.i. in 2021-2022 whereas the use of biopesticide found 71.4 kg a.i. in 2013-2014 to 175.59 kg a.i. in 2021-2022 (PQPMC, 2023) which is very low in quantity. The consumption of biopesticide can raised by advocating the use of biopesticides

and highlighted the misuse, over use and consequences of the chemical pesticides to the farmers and consumers. The consumption of biopesticides over past ten years data shows that very low quantity (Fig. 2). This data includes only consumption of microbial biopesticides. Farmers used yellow traps, lures, and pheromone traps specially in vegetables, citrus, litchi and mango fruits which have not included in consumption data.

Alternatives of synthetic pesticides: There are other alternative approaches of plant protection instead of chemical or synthetic pesticides. The commonly used practices are use of resistant variety of pests and diseases, and climatic shocks, integrated pest management, late or early planting to escape pests, physical barriers to insects, light trap, mixed cropping, crop rotation, grow the healthy crop, use of biopesticides (microbials, semiochemicals, repellents, and botanicals) have gained attention and publicity due to potentially healthier benefits in agriculture and for human health (Gupta & Dikshit, 2010). Biopesticide possesses antifungal, antibacterial, antivirus, and insecticidal properties (Akinbode & Ikotun, 2008; Hao et al., 2021; Harlapur et al., 2010; Yasmin et al., 2008). Fortune Business insight says that the global market value of biopesticide was USD 7.54 billion in 2023 and projected to grow USD 8.73 billion in 2024 to USD 28.61 billion in 2032.

Commercialization of biopesticides is rapidly growing all over the world (Kumar, 2012), but in absence of effective regulations and some other constraints (Arora, 2015), the growth is not as expected.

Pesticide storage burden in the Act: In the article 42 of the Pesticide Management Act, there is provision of storage of seized pesticides in each province until their safe disposal and management. Itis a burden of government for the management of such pesticides. Government has not sufficient qualified manpower, structure and resource for disposal of synthetic pesticides. According to the WHO classification of pesticides (Table1), Nepal has registered the following highly hazardous pesticides (HHPs) and hazardous pesticide, and LD_{50} is less than 100mg/kg body weight which should to think registered and ban. But during the ban of the pesticides, there are other criteria HHPs (Table1) considering those criteria can decide for ban some pesticides among them. The disposal of synthetic pesticide is costly than the production. There is no any problem for the disposal of the biopesticides, they are easily biodegradable. So, encourage to register and use of the biopesticides.

Criteria for HHPs	According to
High acute toxicity (Class 1a, 1b, or "fatal if inhaled"	World Health Organization Globally Harmonized System of Classification and Labelling of Chemicals (GHS)
Long term toxic effects (Known or presumed carcinogenic, mutagenic or reproductive toxicant	International Agency for Research on Cancer United States Environmental Protection Agency GHS
Endocrine disruptor (suspected or potential)	GHS EU priority list
High environmental concern (very persistent or very bio accumulative or very toxic to aquatic organisms)	UN Stockholm Convention UN Montreal Protocol
Hazard to ecosystem services (highly toxic for bees	United States Environmental Protection Agency
Known to cause a high incidence of severe or irreversible adverse effects	UN Rotterdam Convention

Fig. 3. Criteria for Highly hazardous pesticides and reference organization or convention.

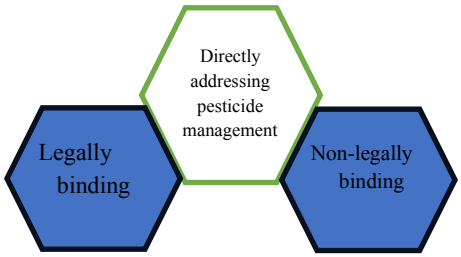
Source: Policy brief of HHPs of Kenya, 2020

Table 1. Highly hazardous and hazardous registered pesticides in Nepal

SN	Common name	Functional group	Chemical family	WHO Class	LD_{50} mg/kg
1.	Abamectin	Insecticide	Micro-organism Derived insecticide	Ib	8.7
2.	Beta-Cyfluthrin	Insecticide	Synthetic Pyrethroids	Ib	11
3.	Cyfluthrin	Insecticide	Pyrethroid insecticide/ Pyrethroid ester insecticide	Ib	15
4.	Bromadiolone	Rodenticide	Coumarin rodenticide	Ia	1.12
5.	Zinc phosphide	Rodenticide	Organic compound	Ib	40.5
6.	Thiodicarb	Insecticide	Carbamates	II	66
7.	Quinalphos	Insecticide	Organophosphate	II	61
8.	Alphacypermethrin	Insecticide	Synthetic Pyrethroids	II	79
9.	Bifenthrin	Insecticide	Synthetic Pyrethroids	II	55
10.	Fipronil	Insecticide	Pyrazole	II	92
11.	Lambda cyhalothrin	Insecticide	Synthetic Pyrethroids	II	56
12.	Propoxur	Insecticide	Carbamate insecticide/ Carbamate acaricide	II	95

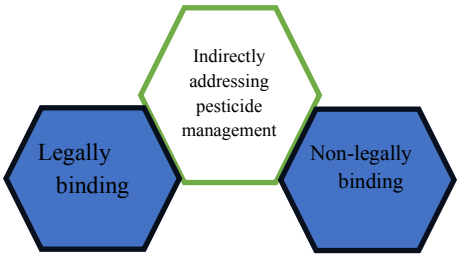
Source: PQPMC,2023

International agreements and guidelines related to pesticides: Nepal became member of some conventions related to pesticide directly addressing the pesticide management and some of them are indirectly addressing the pesticides. Some of them are legally binding and others are not legally binding but are very useful for the pesticide management. The following are related agreements doing accession on pesticides management and food safety. Similarly, FAO and WHO developed a number of guidelines and protocols for proper management of pesticides which thy guide us.



Rotterdam and Stockholm convention Montreal protocol Minamata convention, WTO-SPS and TRIPS

International code of conduct on pesticide management Highly hazardous pesticides Codex Alimentarius Globally harmonizes system of classification on labelling of chemicals Strategic approach to international chemical management (SAICM) WHO



Convention On Biological Diversity (CBD) International Plant Protection Convention (IPPC) Worst Form of Child Labor Convention Occupational Safety and Health Convention

Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IBES)

Registered pesticide category: According to classification of pesticides by hazard groups developed by WHO the registered pesticides in Nepal belong to the following categories:

The data shows that Ia , I_b and a larger number of II hazard group of pesticides are still in use. Alternatives of these pesticides should be explored and restrict the use of highly hazardous pesticides.

Table 2. Registered Pesticides on Hazard Group

Pesticides	WHO Classification						Total
	Ia	Ib	II	III	U	NC	
Insecticide		3	32	12	10	9	66
Acaricide			**2**	**1**	**2**		**5**
Nematicide		3		1		1	2
Fungicide			12	9	19	8	48
Bactericide						1	1
Herbicide			7	10	7	15	39
Rodenticide	1	1					2
Molluscicide			1				1
Biopesticide					15		15
Total	**1**	**4**	**54**	**33**	**53**	**34**	**179**

Source: PQPMC,2023

Market structure of pesticides: As the provision of the pesticide management act, following formulators, importers, applicators and resellers having licenses as pesticide entrepreneurs. There is provision of licensing for importer and formulators from the pesticide management committee and province pesticide management committee has authority to provide licenses for applicators and resellers. Most of the entrepreneurs doing chemical pesticides in their business and some of them started selling biopesticides. The numbers of entrepreneurs on pesticide marketing is shown in Table 3.

Table 3. Pesticide entrepreneurs in Nepal

SN	Pesticide entrepreneurs	Numbers
1.	Pesticide importer	350
2.	Pesticide formulator	8
3.	Pesticide applicator	13
4.	Pesticide reseller	19000

Source: PQPMC, 2023

Pesticide storage burden in the Act: In the article 42 of the pesticide management act, there is provision of storage of seized pesticides in each province until their safe disposal and management. It's a burden to the government for the management of such pesticides. There is a lack of qualified human resources, structure and resource for disposal of those pesticides. The disposal of synthetic

pesticide is costlier than the production. On the other hand, there is no such issue for the disposal of the biopesticides, they are easily biodegradable.

Power to lunch special program: According to article 43 of the Act, the government of Nepal may lunch a special program as an alternative so as to mitigate the possible effect caused from the use of chemical pesticides on the environmental and health of human beings, birds, animals, aquatics and plants.

Procedures and Standards: Article 45 of the Act recommends the development of directives, procedures, and standards to regulate the registration, re-registration, and renewal of pesticides. In line with this provision, the PQPMC is in the process of preparing these procedures and standards to ensure the effective implementation of the Act.

Provisions of promotion of biopesticides in pesticide management Act, 2019: As stated in Article 20 of the Pesticide Management Act, there is provision to encourage the production and use of biopesticides, recognizing their effectiveness in pest management and their safety for human health and the environment. The Rule 20 of the Pesticide Management Regulation further supports this by stipulating that the registration of biopesticides should be completed through a fast-track process, ensuring that approval is granted within 60 days of application, provided all necessary documents are submitted and meet the eligibility requirements. Additionally, this rule allows for certain privileges, such as the submission of documents and registration fees during the registration process while chemical pesticides have significant consequences and impacts when used in agriculture and non-agricultural fields, biopesticides offer several advantages. They are effective in targeting specific pests, are quickly biodegradable, and do not harm natural predators, the environment, or human health. To maximize the benefits of biopesticides, it is crucial to raise awareness among farmers, producers, formulators, and other individuals directly involved in the pesticide production and usage cycle. Educating these stakeholders about the advantages of biopesticides will help promote their adoption and lead to safer, more sustainable pest management practices.

Act and government adopted agro-ecology transformative technologies: There are some provisions in the act for the promotion of domestic and biopesticides and PQPMC has doing some following activities favoring the pesticide reduction, human health and environment protection.

a. **Promotion of bio-pesticide provision in the Act:** The production and distribution of domestic pesticide shall be made in environment friendly manner accordance with article 19 of Pesticide Management Act. Similarly, article 20 provides for the encouragement or production and use of botanical based pesticide for managing different diseases or insects found in plants, home and storage.

Research, academia and development sectors should focus on awareness to the farmers for selection of the best options of prevailing pest, using the personal protective equipment during handling, disposal of container and postharvest interval of commodity.

b. **Biopesticide promotional program:** The FAO supported Community IPM program under the DoA, community IPM resource centers for the mass production of *Trichoderma viride* (antagonistic fungi) and *Heterorhabditis bacteriophora (*a species of entomopathogenic nematode) for biological pest control in Jhapa, Chitwan, Kavre, Tanahun, Banke and Kailali

district. They are producing, using in their own cooperative members' fields and sell especially in winter season according to demand. But due lack of awareness in the farmers about the use of biopesticides, program demand-supply linkage between biopesticide producers and farmers, biopesticide producers and government offices the community resource centers found hard to sustain.

c. Organic certification body: The Government of Nepal, Ministry of Agriculture and Livestock Development prepared the standard and guideline of organic farming and decided to put a secretariat office for the certification of organic product in Department of Food Technology and Quality Control under the MoALD.

d. Organic province declaration: Council of Ministers, Karnali Province decided the whole Karnali Province emphasizes the organic agriculture production and prepared its guidelines.

Gap in the Act and Regulation for Promotion of Biopesticides

After analysis of the pesticide management related policies, pesticide management act and regulation, international conventions and negotiations following gaps were observed:

1. Absence of clear and separate regulatory framework for promotion of biopesticides and found the domination of all management practices related to chemical pesticide, have so many burdens and huddles for the management of the chemical pesticides.
2. More or less similar registration process for all pesticides including biopesticides due to analogy approach for registration.
3. Testing requirements (e.g., biological efficacy, mode of action, target specificity) for registration of biopesticides and specially focusing on field trials which takes more time for registration. It seems over-regulation for low-risk products.
4. There is very limited research on biopesticides because effective biopesticides need to be tailored to specific pest and environmental conditions.
5. Lack of data on mode of action of biopesticides - how they interact with pests or affect non-target organisms, which can make it more difficult to evaluate their safety and efficacy.
6. Inconsistent labeling and packaging requirements due to lack of specific guidelines for biopesticides because pesticide management act and regulation does not spell out about labeling, safe use, storage, and disposal for biological agents.
7. Limited incentives for biopesticides producers and manufacturers, local production, and access to biopesticides for small holding farmers.
8. Lack of comprehensive monitoring systems for biopesticides for ensuring their ongoing safety and effectiveness on health and environment.
9. Lack of awareness and education on the benefits of biopesticides and their proper use and consequences of chemical pesticides to the farmers.
10. Policies to integrate biopesticides into IPM strategies, providing training and education to farmers on how to combine biopesticides with other sustainable practices.

IMPLEMENTATION PLAN FOR PROMOTION OF BIOPESTICIDES IN NEPAL

To reduce the dependency on chemical pesticides, improve environmental and human health, and enhance cost-effective agricultural productivity, it is crucial to promote biopesticides. This can be achieved through targeted programs, including research and development activities to identify

effective biopesticides and evaluate their performance on crops in different agro-ecological zones through pilot trials.

Building farmers' capacity through education, training, demonstrations, and knowledge-sharing tools such as mobile-based advisory platforms can ensure proper understanding of biopesticide application techniques, dosage, and safety measures. A supportive policy and regulatory framework should facilitate the production, registration, approval, and marketing of biopesticides by offering incentives and subsidies to encourage their adoption.

Developing markets, along with strong monitoring and evaluation systems, is essential. This includes conducting interviews with farmers to assess the effectiveness of biopesticides, identifying challenges, and understanding their impact on soil health and biodiversity. Engaging stakeholders, strengthening collaboration, and promoting regional and international cooperation are also critical for successful biopesticide promotion. Implementing a well-defined timeline with specific milestones will ensure reduced reliance on chemical pesticides, improved agricultural productivity, and enhanced environmental sustainability.

Table 4. Timeline and milestones

Phase	Timeframe (Months)	Key milestones	Responsible organization
Research and development	6-12	Selection of biopesticides, successful pilot trials for their efficacy on pest control	University, PQPMC and Nepal Agricultural Research Council
Assessment of the current situation for protection of pollinators	6-12	Rapid assessment to be carried out for protection of pollinators from the pesticides, identify the priority action and implementation	PQPMC and Central for Industrial Entomology Development
Ban of highly hazardous pesticides (HHPs)	12-18	Some HHPs should to ban by the pesticide management committee	Pesticide Management Committee
Capacity building	12-18	Training programs implemented; farmer education reached on nature-based solutions	Pesticide Management Committee and PQPMC
Policy and regulatory framework	12-18	Regulatory frameworks set, protocol approval of biopesticides, preparation of guidelines for registration	Pesticide Management Committee and PQPMC
Market development	12-18	Partnerships with distributors, public awareness campaign launched for promotion of nature- based plant protection techniques.	Producers, pesticide entrepreneurs and farmers
Monitoring an evaluation	Ongoing after six months	Continuous feedback, assessment reports published in different time interval	PQPMC

CONCLUSIONS

Nepal does not have the pesticide production industry and have only 8 numbers of formulators. Analogy approach is used for pesticide registration due to a smaller number of staffs and resources involved for registration of pesticides. Both neighboring countries produce a big number of pesticides and 179 technical (common name) pesticides are registered in Nepal. In the earlier pesticide act there was not the provision of educational qualification for involvement in the pesticide business. Majority of the farmers contact the pesticide retailors for advisory service on pests' problems. Due to lack of knowledge on handling of pesticide during mixing, spraying, using personal protective equipment, re-entry interval, post-harvest interval and disposal of the containers, its acute and chronic effects have negatively impacted in the human health and environment. On the other hand, there are a lot of nature-based solutions to reduce the population of insects, weeds and disease problems which are nature friendly and do not harm our health. Use of resistant varieties, grow healthy crop, crop rotation, mulching, conservation agriculture, mixed and relay cropping, organic farming, natural farming, modern integrated pest management, use of biopesticides can contribute to reduce the use of synthetic pesticides. Still our act, regulation and guidelines need to be more supportive to the use of Nature based solutions being more restrictive to the chemical pesticides.

RECOMMENDATIONS

The following are the major strategies for promoting biopesticides:

1. Awareness and education campaign in the local and community level should be conducted through public awareness, farmer outreach and highlighting the success stories.
2. Capacity building and technical support by training to the front line extension workers, work on research and development jointly and make mechanism on certification, incentives for manufacturers and producers, provide subsidies and financial support.
3. Collaboration with private sector, farmers' cooperatives and biopesticide producing companies for production, labeling, branding, and marketing.
4. Incentivizing the sustainable practices through promotion of integrated pest management practices, and support in organic farming.
5. Support to smallholder farmers for affordable access of biopesticides, localized solutions, and financial mechanism.
6. International cooperation and knowledge sharing by making global networks and platforms, technology transfer and synchronize the international trade agreements.
7. Regular monitoring and impact assessment in certain time by evaluation of effectiveness and long-term studies.
8. Consumer demand creation
9. Make the registration process faster for the bio-pesticides considering its ecofriendly nature and should to deregister or banned whose LD_{50} less than 100mg /kg body weight.
10. Develop the traceability and certification mechanisms of naturally produced farming and product marketing

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