International Journal of Scientific Engineering and Science
Volume 8, Issue 9, pp. 9-11, 2024. ISSN (Online): 2456-7361

Biopesticides: A Review on It's Development

K. P. Dandge
Department of Environmental Science, School of Environmental and Earth Sciences, Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon 425001 (M.S.) India

Abstract*—There is an urgent need to develop eco-friendly strategies for combating insect pests. These strategies should focus on controlling pest populations using naturally occurring substances, such as plant and animal extracts, microorganisms, parasitic nematodes and insects, and specific minerals. The overuse and misuse of chemical pesticides have resulted in pest resistance, the destruction of beneficial organisms, and increased residual problems, posing significant threats to both the environment and human health. This has led the scientific community to explore the potential of biopesticides. Currently, viruses, fungi, parasitic nematodes, and certain strains of Bacillus thuringiensis are available for commercial use. Utilizing biopesticides as biocontrol agents presents a promising alternative, particularly if challenges related to phytopathogens and environmental issues caused by synthetic pesticides can be effectively managed. This review highlights current practices and advancements in the use of biopesticides on both regional and global levels.*

***Keywords*—** *Biopesticides, Eco-friendly, Pests, Pesticide.*

I. Introduction

Biopesticides are target specific, having low toxicity to nontarget organisms, minimal persistence in the environment and potentially usable in organic agriculture (Seiber et al., 2014a). Scientific developments and key fluctuations in the outer ecosystem have positively changed the prospect for biopesticides (Glare et al., 2012). Interruption in breeding due to synthetic pheromones will continue to be a key role within crop protection and there is indication of some notable successes in control of different pests on cotton plants (Copping & Menn, 2000). When used effectively, biopesticides can significantly enhance the sustainability of global agriculture, ensuring both food and feed security (S. Kumar & Singh, 2015). In India agriculture area under organic cultivation is estimated approximately one lakh hectares. Furthermore, the region under organic farming may increase because of the growing need of organic food, a result of rising health awareness among the people. This signifies that there is enormous opportunity for growth of the biopesticide sector in India (Gupta & Dikshit, 2010).

II. Advantages of Biopesticides

Biopesticides typically exhibit lower toxicity compared to conventional pesticides. These pesticides mainly affect the target pest and the organisms that are closely related to it, unlike broad-spectrum, conventional pesticides that affect the most sensitive organisms such as birds, insects and animals. mammal. Biopesticides are often effective as they break down quickly, reduce exposure and avoid the contamination problems of conventional pesticides. When integrated into pest management programs, biopesticides can greatly reduce the reliance on conventional pesticides while maintaining high crop yields (EPA, 2022). The double advantage of biopesticides and invention in associated technology can provide operative solution against the pest insects, it ultimately minimizes agricultural losses (Kala et al., 2020). The related studies by (Arjjumend et al., 2020) in Ukrainian agroecosystems revealed that farmers produced better quality fruits, grains, and tubers with an extended shelf lifespan by using of biopesticides. Other side, the risk of crop loss remains high if crops are grown using chemical pesticides, this risk is reduced up to 33% on average if crops are grown using biopesticides.

III. Disadvantages of Biopesticides

A. Obtainability and Dose

Biopesticides, which are derived from natural sources, offer a promising alternative to synthetic pesticides. Unlike conventional pesticides, biological pesticides are generally less toxic and more sensitive. They affect only the intended pest and closely related organisms, minimizing harm to beneficial insects, animals, and the environment (US EPA, 2024). However, availability remains a significant drawback for biopesticides, as they are only accessible in certain places and at specific times, causing hindrances and longer waiting periods.

B. Target Specific

Biopesticides have a shorter shelf life, typically a few months, whereas conventional pesticides can last up to 2 years. To use biopesticides effectively, one needs greater knowledge and understanding of their application (Ayilara et al., 2023). On the positive side, biopesticides can be more specific in targeting pests without harming non-target organisms.

C. Efficiency and Persistence

While biopesticides have advantages, they may exhibit lower efficacy and persistence compared to conventional pesticides. This means that the results obtained from biopesticide usage might be less satisfactory than those achieved with traditional pesticides (Grady Moore, 2024). In summary, biopesticides offer a safer and more environmentally friendly option, but their limitations require careful consideration when implementing pest management strategies.

IV. Current Scenarios

Biopesticides are increasingly favored over synthetic

pesticides for pest control due to their diverse modes of action. These natural alternatives help prevent the development of resistance in pests. In a country like India, with a large number of plant species, there is an urgent need to identify new pesticides that directly address the challenges of pest management (Tripathi et al., 2020). In developing countries, the establishment of robust quality control systems and the accessibility of affordable pesticides are crucial factors. Consequently, it is essential to regularly assess various aspects of biopesticides, including their current status, challenges, opportunities, and the network for effective utilization. This ongoing review ensures that biopesticides contribute positively to the well-being of humanity (Manjusha Tyagi & Anamika Rana, 2022). While biopesticides are gradually replacing chemical pesticides, a global overview reveals that the biopesticide industry remains relatively insecure compared to the dominant chemical counterparts in agriculture (Mishra et al., 2015). It's now essential to promote the use of these microbial biopesticides to farmers around the globe (Thakur et al., 2020). In India, the primary biopesticides produced and utilized include neem-based pesticides, Bacillus thuringiensis and Trichoderma. These biopesticides are notable for being eco-friendly and easily biodegradable, resulting in lower toxic residues and significantly reducing pollution problems associated with chemical pesticides. Additionally, incorporating biopesticides into an Integrated Pest Management program can greatly reduce the use of conventional pesticides while maintaining nearly the same level of crop yield (Dar et al., 1998). The adoption of microbial- and nematode-based biopesticides is hindered by several factors, including high production costs, limited action spectra, vulnerability to environmental conditions, short shelf life, poor storage stability, regulatory constraints, and a general lack of knowledge. In recent years, significant advancements have been made in biopesticide production (Hamrouni et al., n.d.). Biopesticides are gaining global attention as a safer alternative to synthetic pesticides. They pose less risk to both people and the environment while effectively targeting insects, plant pathogens, and weeds (Mehrotra et al., 2017).

V. Recent Advances

Botanical pesticides, derived from specific plant parts or active ingredients, have been used for insect control, sterilization, weed management, and regulating plant growth. Their development primarily relies on the secondary metabolites of plants, such as flavonoids and alkaloids (Leng et al., 2011). Nanotechnology has been utilized to create stable biopesticide nano-formulations with prolonged effects and to synthesize environmentally friendly inorganic nanomaterials that possess antimicrobial, antifungal, and antiparasitic properties (Abdollahdokht et al., 2022). Although great progress has been made in developing formulations and application methods, more research is needed to optimize the use of biological pesticides to protect plants (Sunjka and Mechora, 2022). To date, a vast array of plant secondary metabolites has been identified, with some already available on the market. For instance, nicotine, azadirachtin, matrine, rotenone, veratrine, limonene, pyrethrin, and Celastrus angulatus are used to control insect pests. Berberine, ethylicin, Cnidium lactone, physcion, and carvacrol are effective against plant diseases. Brassinolide influences plant growth and development, while triptolide and curcumenol are used for rat control (Liu et al., 2021). Using essential oil-based bio-pesticides is advantageous due to their low toxicity to mammals and minimal environmental persistence. Their short residual half-lives on plants make them compatible with biological control agents and natural enemies of pests, while also reducing the risk of harm to foraging pollinators like honeybees (Assadpour et al., 2024).

VI. Future perspectives

The use of biopesticides and alternative management products is on the rise. New tools such as semiochemicals, plant-incorporated protectants, botanical and microbially derived chemicals are becoming increasingly important in pest management. These tools are complemented by advancements in plant and animal genetics, biological control, cultural methods, and newer synthetic options (Seiber et al., 2014b). The future of biorational products looks promising as more farmers and consumers recognize the benefits of eco-friendly solutions. The adoption rate of these products is rising, driven by stringent regulations on chemical pesticides in many countries, which are encouraging a shift towards more sustainable and safer alternatives (Anjum et al., 2024). To fully harness the potential of biopesticides and convince farmers of their efficiency and eco-friendliness compared to conventional chemical pesticides, more focused research is needed in production, formulation, and the development of effective delivery systems (Katti, 2013). It is strongly recommended that farmers use biopesticides, as research has shown them to be safer for crops, the environment, and even the health of the farmers themselves. Additionally, future approaches to managing crop pests should include integrated pest management (IPM), which employs a variety of techniques to effectively control pests while minimizing disruption to the agricultural ecosystem (Agboola et al., 2022).

VII. Conclusion

Biopesticides are a powerful tool in the fight against pests and in reducing pesticide pollution. Their importance in modern agriculture cannot be overstated. With their eco-friendly nature, targeted pest control, and diverse roles in managing insects and diseases, biopesticides are essential for sustainable farming practices. Nanotechnology-based microencapsulation could enhance the residual action of biopesticides, increasing their effectiveness in the field. Biopesticides are expected to play an important role in the pesticide market and provide opportunities for growth and diversification in the agricultural sector, thanks to biotechnological advances and better policies. Globally, researchers have conducted studies on the effectiveness of natural plant protection products, with significant results from in vitro experiments. There are also studies on the effectiveness of biopesticides under controlled environments and field conditions, with varying outcomes. Further research

is recommended to address gaps in biopesticide formulation. As agriculture continues to grow, the use of biological pesticides is an important way to be sustainable and environmentally conscious.

REFERENCES

[1] Abdollahdokht, D., Gao, Y., Faramarz, S., Poustforoosh, A., Abbasi, M., Asadikaram, G., & Nematollahi, M. H. (2022). Conventional agrochemicals towards nano-biopesticides: an overview on recent advances. In *Chemical and Biological Technologies in Agriculture* (Vol. 9, Issue 1). Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1186/s40538-021-00281-0

[2] Agboola, A. R., Okonkwo, C. O., Agwupuye, E. I., & Mbeh, G. (2022). Biopesticides and Conventional Pesticides: Comparative Review of Mechanism of Action and Future Perspectives. *AROC in Agriculture*, *1*(1), 14–32. https://doi.org/10.53858/arocagr01011432

[3] Anjum, B., Thakuri, S. C., Panwar, M., Jahan, T., Juyal, V. K., Rashmi, & Nand, V. (2024). Chapter 2 Global current scenario and future prospectus of biorationals. In R. Kumar, M. S. de Oliveira, E. H. de Aguiar Andrade, D. C. Suyal, & R. Soni (Eds.), *Pest Management* (pp. 23–46). De Gruyter. https://doi.org/doi:10.1515/9783111204819-002

[4] Arjjumend, H., Koutouki, K., & Donets, O. (2020). Comparative Advantage of Using Biopesticides in Ukrainian Agroecosystems. *European Journal of Agriculture and Food Sciences*, *2*(6 SE-Articles). https://doi.org/10.24018/ejfood.2020.2.6.183

[5] Assadpour, E., Can Karaça, A., Fasamanesh, M., Mahdavi, S. A., Shariat-Alavi, M., Feng, J., Kharazmi, M. S., Rehman, A., & Jafari, S. M. (2024). Application of essential oils as natural biopesticides; recent advances. In *Critical Reviews in Food Science and Nutrition* (Vol. 64, Issue 19, pp. 6477–6497). Taylor and Francis Ltd. https://doi.org/10.1080/10408398.2023.2170317

[6] Ayilara, M. S., Adeleke, B. S., Akinola, S. A., Fayose, C. A., Adeyemi, U. T., Gbadegesin, L. A., Omole, R. K., Johnson, R. M., Uthman, Q. O., & Babalola, O. O. (2023). Biopesticides as a promising alternative to synthetic pesticides: A case for microbial pesticides, phytopesticides, and nanobiopesticides. In *Frontiers in Microbiology* (Vol. 14). Frontiers Media SA. https://doi.org/10.3389/fmicb.2023.1040901

[7] Copping, L. G., & Menn, J. J. (2000). Biopesticides: A review of their action, applications and efficacy. *Pest Management Science*, *56*(8), 651–676. https://doi.org/10.1002/1526-4998(200008)56:8<651: AID-PS201>3.0.CO;2-U

[8] Dar, S. A., Khan, Z. H., Khan, A., & Ahmad, B. (1998). Biopesticides-Its Prospects and Limitations: An Overview. In *Perspectives in Animal Ecology and Reproduction*.

[9] EPA. (2022). *Biopesticides*. Pesticides. https://www.epa.gov/ingredients-used-pesticide-products/what-are-biopesticides#:~:text=Biopesticides are certain types of,applications and are considered biopesticides.

[10] Glare, T., Caradus, J., Gelernter, W., Jackson, T., Keyhani, N., Köhl, J., Marrone, P., Morin, L., & Stewart, A. (2012). Have biopesticides come of age? *Trends in Biotechnology*, *30*(5), 250–258. https://doi.org/https://doi.org/10.1016/j.tibtech.2012.01.003

[11] Grady Moore. (2024). The Future of Biopesticides. *AgriTechTomorrow*.

[12] Gupta, S., & Dikshit, A. K. (2010). Biopesticides: An ecofriendly approach for pest control. *Journal of Biopesticides*, *3*(1 SPEC.ISSUE), 186–188.

[13] Hamrouni, R., Regus, F., Farnet Da Silva, A.-M., Orsiere, T., Boudenne, J.-L., Laffont-Schwob, I., Christen, P., & Dupuy, N. (n.d.). Current status and future trends of microbial and nematode-based biopesticides for biocontrol of crop pathogens. *Critical Reviews in Biotechnology*, 1–20. https://doi.org/10.1080/07388551.2024.2370370

[14] Kala, S., Sogan, N., Agarwal, A., Naik, S. N., Patanjali, P. K., & Kumar, J. (2020). *Chapter 18 - Biopesticides: Formulations and Delivery Techniques* (C. Egbuna & B. B. T.-N. R. for P. Sawicka Disease and Weed Control, Eds.; pp. 209–220). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-819304-4.00018-X

[15] Katti, G. (2013). Biopesticides for Insect Pest Management in Rice-Present Status and Future Scope. *Journal of Rice Research*, *6*(1), 1–15.

[16] Kumar, S., & Singh, A. (2015). Biopesticides: Present Status and the Future Prospects. *Journal of Biofertilizers & Biopesticides*, *06*(02), 2–4. https://doi.org/10.4172/jbfbp.1000e129

[17] Leng, P., Zhang, Z., Pan, G., & Zhao, M. (2011). Applications and development trends in biopesticides. In *African Journal of Biotechnology* (Vol. 10, Issue 86, pp. 19864–19873). https://doi.org/10.5897/AJBX11.009

[18] Liu, X., Cao, A., Yan, D., Ouyang, C., Wang, Q., & Li, Y. (2021). Overview of mechanisms and uses of biopesticides. In *International Journal of Pest Management* (Vol. 67, Issue 1, pp. 65–72). Taylor and Francis Ltd. https://doi.org/10.1080/09670874.2019.1664789

[19] Manjusha Tyagi, & Anamika Rana. (2022). Current Scenario of Biopesticides in India. *Advances in Bioresearch*, *13*(1), 177–183. https://doi.org/10.15515/abr.0976-4585.13.1.177183

[20] Mehrotra, S., Kumar, S., Zahid, M., & Garg, M. (2017). Biopesticides. In R. L. Singh (Ed.), *Principles and Applications of Environmental Biotechnology for a Sustainable Future* (pp. 273–292). Springer Singapore. https://doi.org/10.1007/978-981-10-1866-4_8

[21] Mishra, J., Tewari, S., Singh, S., & Arora, N. K. (2015). Biopesticides: Where We Stand? In N. K. Arora (Ed.), *Plant Microbes Symbiosis: Applied Facets* (pp. 37–75). Springer India. https://doi.org/10.1007/978-81-322-2068-8_2

[22] Seiber, J. N., Coats, J., Duke, S. O., & Gross, A. D. (2014a). Biopesticides: State of the Art and Future Opportunities. *Journal of Agricultural and Food Chemistry*, *62*(48), 11613–11619. https://doi.org/10.1021/jf504252n

[23] Seiber, J. N., Coats, J., Duke, S. O., & Gross, A. D. (2014b). Biopesticides: State of the Art and Future Opportunities. *Journal of Agricultural and Food Chemistry*, *62*(48), 11613–11619. https://doi.org/10.1021/jf504252n

[24] Šunjka, D., & Mechora, Š. (2022). An Alternative Source of Biopesticides and Improvement in Their Formulation—Recent Advances. In *Plants* (Vol. 11, Issue 22). MDPI. https://doi.org/10.3390/plants11223172

[25] Thakur, N., Kaur, S., Tomar, P., Thakur, S., & Yadav, A. N. (2020). Chapter 15 - Microbial biopesticides: Current status and advancement for sustainable agriculture and environment. In A. A. Rastegari, A. N. Yadav, & N. Yadav (Eds.), *New and Future Developments in Microbial Biotechnology and Bioengineering* (pp. 243–282). Elsevier. https://doi.org/https://doi.org/10.1016/B978-0-12-820526-6.00016-6

[26] Tripathi, Y. N., Divyanshu, K., Kumar, S., Jaiswal, L. K., Khan, A., Birla, H., Gupta, A., Singh, S. P., & Upadhyay, R. S. (2020). Biopesticides: Current Status and Future Prospects in India. In C. Keswani (Ed.), *Bioeconomy for Sustainable Development* (pp. 79–109). Springer Singapore. https://doi.org/10.1007/978-981-13-9431-7_6

[27] US EPA. (2024). *Ingredients Used in Pesticide Products*. Biopesticides and Pollution Prevention Division.