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BIOPESTICIDES AS A PATHWAY TOWARDS SUSTAINABLE GREENER WORLD

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ABSTRACT: Biopesticides are ecofriendly pesticides which are obtained from naturally occurring substances(biochemicals), microbes and plants. Through the use of biopesticides in a wider way, agriculture and health programmes can be beneficially affected. There are many disadvantages associated with the use of chemical pesticides like genetic variations in plant populations, reduction of beneficial species, damage to the environment or water bodies, poisoning of food and health problems such as cancer which makes biopesticides to come into picture. Their usage reduces risk of exposure tochemicals, reduces water pollution through fertilizer runoff, reduces number of applications, causes less harm to beneficial pests, biodegradable, provides better nutritional quality. In India, there are many locally available plants like beshram, neem, garlic, triphala, pinus kesia etc which can be easily processed and increase the biopesticide consumption in India. However, some of the biopesticides like Bt, NPV, neem based pesticides, Trichoderma etc. have already been registered and are being practiced. This paper highlights role of biopesticides in agriculture and potential biopesticides availabile in India with establishment of biopesticide units in rural areas.

KEYWORDS: Biopesticides; Biodegradable; Sustainable; Trichoderma.

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1.INTRODUCTION

Agriculture plays a vital role in a developing country like India. Apart from fulfilling the food

requirement of the growing Indian population, it also plays a role in improving economy of the country. The Green Revolution technology adoption between 1960 to 2000 has increased wide varieties of agricultural crop yield per hectare which increased 12-13% food supply in developing countries [1,2]. Growth of biopesticides is projected to outpace that of chemical pesticides, with compounded annual growth rates of more than 15% [3]. It is expected that biopesticides will equalize with synthetics, in terms of market size, between the late 2040s and the early 2050s, but major uncertainties in the rates of uptake, especially in areas like Africa and Southeast Asia, account for a major portion of the flexibility in those projections [4].Southeast Asia and India were the first developing countries to show the impact of GR on varieties of rice yields. Inputs like fertilisers, pesticides helped a lot in this regard. But inspite of this fact, food insecurity and poverty still prevails prominantly in our country. Use of chemical biopesticides and fertilisers have caused negative impact on environment by affecting soil fertility,water hardness, development of insect resistance,genetic variation in plants, increase in toxic residue through food chain and animal feed thus increasing health problems and many more. This has made it essential to introduce measures which can harness foresaid challenges. Use of biopesticides and biofertilizers can play a major role in dealing with these challenges in a sustainable way. My focus in this paper will be on use of conventional biopesticides.

2. RESULTS AND DISCUSSION

2.1. Pesticides and environmental safety

Biopesticides are biochemical pesticides that are naturally occurring substances that control pests by nontoxic mechanisms. Biopesticides are living organisms (natural enemies) or their products (phytochemicals, microbial products) or byproducts (semiochemicals) which can be used for the management of pests that are injurious to plants. They pose less threat to the environment and to human health. The most commonly used biopesticides are living organisms, which are pathogenic for the pest of interest. These include biofungicides (*Trichoderma*), bioherbicides (*Phytopthora*) and bioinsecticides (*Bacillus thuringiensis*) [5]. There are few plant products also which can now be used as a major biopesticide source. Plant-incorporated protectants include substances that are produced naturally on genetic modification of plants. Such examples are incorporation of Bt gene, protease inhibitor, lectines, chitinase etc into the plant genome so that the transgenic plant synthesizes its own substance that destroys the targeted pest. The potential benefits to agriculture and public health programmes through the use of biopesticides are considerable. The interest in biopesticides is based on the advantages associated with such products which are:

- Inherently less harmful and less environmental load,

- Designed to affect only one specific pest or, in somecases, a few target organisms,

Often effective in very small quantities and often decompose quickly, thereby resulting in lower exposures and largely avoiding the pollution problems and When used as a component of Integrated Pest Management Programs (IPM), biopesticides can contribute greatly.

2.2. Indian scenario of biopesticides

Biopesticides represent only 2.89% (as on 2005) of the overall pesticide market in India and is expected to increase drastically in coming years. In India, so far only 12 types of biopesticides have been registered under the Insecticide Act, 1968. Neem based pesticides, *Bacillus thuringensis*, NPV and *Trichoderma* are the major biopesticides produced and used in India. Whereas more than 190 synthetics are registered for use as chemical pesticides. Most of the biopesticides find use in public health, except a few that are used in agriculture. Besides, i) transgenic plants and ii) beneficial organisms called bio-agents: are used for pest management in India.

Table 1. Biopesticides registered as Insecticides Act, 1968

Sl. No.	Name of biopesticides
1.	Bacillus thuringiensis var. israelensis
2.	Bacillus thuringiensis var. kurstaki
3.	Bacillus thuringiensis var. galleriae
4.	Bacillus sphaericus
5.	Trichoderma viride
6.	Trichoderma harzianum
7.	Pseudomonas fluoresens
8.	Beauveria bassiana
9.	NPV of Helicoverpa armigera
10.	NPV of Spodoptera litura
11.	Neem based pesticides
12.	Cymbopogan

2.3. Adoption of biopesticides from from plants

Use of botanicals is now emerging as one of the important means to be used in protection of crop produce and the environment from pesticidal pollution, which is a global problem.

Table 2. Plant products registered as biopesticides

Plant products registered as biopesticides	**Target pests**
Limonene and Linalool	Fleas, aphids and mites,also kill fire ants, several types of flies, paper wasps and house crickets
Neem	A variety of sucking and chewing insect

Pyrethrum / Pyrethrins	Ants, aphids, roaches, fleas, flies, and ticks
Rotenone	Leaf-feeding insects, such as aphids, certain beetles (asparagus beetle, bean leaf beetle, Colorado potato beetle, cucumber beetle, flea beetle, strawberry leaf beetle, and others) and caterpillars, as well as fleas and lice on animals
Ryania	Caterpillars (European corn borer, corn earworm, and others) and thrips
Sabadilla	Squash bugs, harlequin bugs, thrips, caterpillars, leaf hoppers, and stink bugs

Neem is regarded as the most effective and ecofriendly Neem products are effective against more than 350 species of arthropods, 12 species of nematodes, 15 species of fungi, three viruses, two species of snails and one crustace and species. Neem can be a very effective source in India where its production is an easy job**.**

Vrakshayurveda is traditional Indian knowledge of plants like sowing techniques, plant propagation techniques including pest and disease management/preventive and promotive care to build up disease resistance and to cultivate healthy plants [6]. Extracts of plants like neem, garlic, onion, persian lilac, turmeric, ginger, tobacco, papaya, leucas, pongam, tulasi, aloe, custard apple, vitex, sweetflag, poison nut, calotropis etc and their effects on curing plant diseases have been tested by Centre for Indian Knowledge Systems, 30, Gandhi Mandapam Road, Kotturpuram,Chennai – 600 085. India. Table 3 represents such potential biopesticides: Table 3 represents some potential biopesticides in context of Indian scenario and effective against some diseases where traditional pesticides can also act but with a lesser effect and affects due to its high chemical selectivity.

Table 3. Potential biopesticides

Plant Extract	Effective against
Adathoda kashayam and Pudhina kashayam	Leaf folder, bacterial leaf blight, Helminthosporium leaf spot
Thriphala kashayam	Bacterial leaf blight and Helmintho sporium
Andrographis kashayam and Sida kashayam	Aphids and borers in brinjal, ladies finger
Barley Sesamum Horsegram kashayam	Acts as fruit yield enhancer
Cow’s urine arkam & Sweet flag arkam	Bacterial leaf blight, Helminthosporium leaf spot, vein clearing disease, fusarium wilt
Garlic arkam	Leaf folder, bacterial leaf blight, Helminthosporium leaf spot
Neem seed extract(for all crops)	Leaf folder, aphids, Jassids, fruit borer and stem borer

2.4. Limitations

Farmers are used to pesticides which are packaged and available from the shelf. Even though farmers realise the importance of using plant products as alternatives to chemical pesticides, the widespread use of these plant products will take a while to become very popular. One of the ways by which they can be popularised is to process it and make it available to the farmers in a readily usable form [7,8].

2.5. Regulation of biopesticides

Several stakeholders, including scientists, regulators, marketers, and end-users, are involved in the development and commercialization chain of pest control products. Some participants in this chain are often involved from the earliest stages of the development process, but there are many issues still to be resolved; the marketers may often disagree with the regulators and scientists, such that end-users are often puzzled by perceived weaknesses in the final product. Data requirements for biological products are usually acquired from those derived for synthetic chemicals. For biopesticides, however, the assessment of risk should be based on scientific evidence appropriate to the substance, and should not follow rules pertaining to synthetic chemicals. Therefore, an adaptation of the requirements tailored to the nature of the various categories used in biopesticide active substances is required. Currently, data requirements and guidance documents are being properly adapted for biopesticides [9]. Submission procedures both at EU and Member State levels are lengthy, which seems to be the most pressing problem for the biocontrol industry. Considering that if new products are able to reach the market quickly, they will generate income, then faster procedures and enforcement of time limits are important. Moreover, the high cost related to the registration of new agents is another aspect limiting the commercialization of new products [10]. It appears that the registration process of biopesticide products impedes the commercialization of these products. Therefore, the regulatory authorities should try to ensure fast-track registration of biopesticide products based on justified regulations, promoting the adoption of safer technologies in the development of commercial products. Additionally, the regulatory system should enable small and medium-sized firms dealing with biopesticides to develop, so that they can provide growers with reliable tools for the economical control of pests, and allow them to provide products that meet the expectations of consumers.

2.6. Applications in nanotechnology field

Several studies have reported an enhancement in the efficacy of certain biological substances on pests, a decrease in toxicity towards humans and the environment, and a reduction of losses due to Agriculture 2018, 8, 13 4 of 6 physical degradation (e.g., volatilization and leaching) with the encapsulation of these substances in nanoparticulate systems [11–13]. Thus, nanotechnology could contribute to the development of less toxic biopesticides with favorable safety profiles and increased stability of the active agents, enhanced activity on target pests, and increased adoption by the end-

users. Research has shown that the use of nanoparticles is effective in protecting neem (Azadirachta indica) oil from rapid degradation, allowing a prolonged effect on target pests. Because the polymers used in this kind of formulation are biodegradable, continuous delivery of the active agent with low environmental harm is achieved. Future research must target ways of circumventing the risk factors associated with nanoparticle usage, because currently comprehensive knowledge of risk assessment factors and further toxicity of nanoparticles towards agroecosystem components after their release into the environment is lacking [14]. Overall, nanobiotechnology seems promising in the direction of formulations that can be used to improve the stability and effectiveness of natural products [15]. Such formulations can provide controlled release of the molecules at the site of action, can minimize potential toxic effects on non-target organisms, and can prevent degradation of the active agent by microorganisms [16,17]. While there is certainly industrial activity aimed in this direction, the technology is still far from proven, with major questions persisting around release rates, storage stability, and cost effectiveness.

3. CONCLUSIONS

Biopesticides have long been attracting global attention as a safer strategy than chemical pest control, with potentially less risk to humans and the environment [18-22]. To this end, co-operation between the public and private sectors is required to facilitate the development, manufacturing, and sale of this environmentally friendly alternative [23-25]. In this context, discovery of new substances and research on formulation and delivery would boost commercialization and use of biopesticides [27-30].p Additional research on integrating biological agents into common production systems is necessary. Maintaining low cost to farmers for a given product quality and availability, particularly in developing countries, is also important [31]. Moreover, regulations that promote registration of low-risk compounds with provision of Agriculture. Incentives could also facilitate commercialization and availability of biopesticides in the market. While new substances could serve as a promising option for use in pest control, more field research is required to assess the efficacy on specific pest problems in various cropping systems. Microencapsulation based on nanotechnology could improve the residual action of biopesticides, and this could increase their field use. India's rich biodiveristy is an ace factor, always providing a wide source of biopesticides which can be effectively used in agriculture at a large scale. Also increasing helth consciousness of Indian citizens have created a demand of organic food. This indicates huge scope for growth of Bio-pesticides sector. The rich traditional knowledge base available with the highly diverse indigenous communities in India may provide valuable clues for developing newer and effective biopesticide. The stress on organic farming and on residue free commodities would certainly warrant increased adoption of biopesticides by the farmers.

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CONFLICT OF INTEREST

Author declares no conflict of interest.

REFERENCES

1. Biopesticides and Biofertilizers: Ecofriendly Sources for Sustainable Agriculture,article in journal, J Biofertil Biopestici Volume 4, Issue 1,1000e112.
2. Gupta S.,Biopesticides: An eco-friendly approach for pest control, Journal of Biopesticides 3(1 Special Issue) 186 - 188 (2010).
3. Marrone, P.G. The market and potential for biopesticides. In Biopesticides: State of the Art and Future Opportunities; Gross, A.D., Coats, J.R., Duke, S.O., Seiber, J.N., Eds.; American Chemical Society: Washington, DC, USA, 2014; pp. 245–258.
4. Olson, S. An analysis of the biopesticide market now and where is going. Outlooks Pest Manag. 2015, 26, 203–206.
5. Mazid S., Rajkhowa R., Kalita J. A Review on use of Biopesticides in Insect Management, International Journal of Science and Advanced Technology (ISSN 2221-8386) Volume 1 No 7 September 2011 .
6. Balasubramanian, A. V., Arumugasamy, S., Vijayalakshmi, K. & Subhashini Sridhar,article "Plant Products as Biopesticides: Building On Traditional Knowledge Of Vrkshayurveda: Traditional Indian Plant Science",in 16th IFOAM Organic World Congress, Modena, Italy, June 16-20, 2008.
7. Pavela, R. Limitation of plant biopesticides. In Advances in Plant Biopesticides; Singh, D., Ed.; Springer Publishing: New Delhi, India, 2014; pp. 347–359.
8. Isman, M.B. A renaissance for botanical insecticides? Pest Manag. Sci. 2015, 71, 1587–1590.
9. Czaja, K.; Góralczyk, K.; Struci ´nski, P.; Hernik, A.; Korcz, W.; Minorczyk, M.; Łyczewska, M.; Ludwicki, J.K. Biopesticides—Towards increased consumer safety in the European Union. Pest Manag. Sci. 2015, 71, 3–6.
10. Balog, A.; Hartel, T.; Loxdale, H.D.; Wilson, K. Differences in the progress of the biopesticide revolution between the EU and other major crop-growing regions. Pest Manag. Sci. 2017, 73, 2203–2208,
11. De Oliveira, J.L.; Campos, E.V.R.; Bakshi, M.; Abhilash, P.C.; Fraceto, L.F. Application of nanotechnology for the encapsulation of botanical insecticides for sustainable agriculture: Prospects and promises. Biotechnol. Adv. 2014, 32, 1550–1561.
12. Bakry, A.M.; Abbas, S.; Ali, B.; Majeed, H.; Abouelwafa, M.Y.; Mousa, A.; Liang, L. Microencapsulation of oils: A comprehensive review of benefits, techniques, and applications. Compr. Rev. Food Sci. Food Saf. 2016, 15, 143–182.

13. Giongo, A.M.M.; Vendramim, J.D.; Forim, M.R. Evaluation of neem-based nanoformulations as alternative to control fall armyworm. Ciênc. Agrotec. 2016, 40, 26–36.
14. Mishra, S.; Keswani, C.; Abhilash, P.C.; Fraceto, L.F.; Singh, H.B. Integrated approach of agri-nanotechnology: Challenges and future trends. Front. Plant Sci. 2017, 8, 471.
15. Agrawal, S.; Rathore, P. Nanotechnology pros and cons to agriculture: A review. Int. J. Curr. Microbiol. Appl. Sci. 2014, 3, 43–55.
16. Gogos, A.; Knauer, K.; Bucheli, T.D. Nanomaterials in plant protection and fertilization: Current state, foreseen applications, and research priorities. J. Agric. Food Chem. 2012, 60, 9781–9792.
17. Durán, N.; Marcato, P.D. Nanobiotechnology perspectives. Role of nanotechnology in the food industry: A review. Int. J. Food Sci. Technol. 2013, 48, 1127–1134.
18. Khater, H. F. (2012) Prospects of botanical biopesticides in insect pest management. Pharmacologia, 3(12): pp. 641–656.
19. Harding, D. P., & Raizada, M. N. (2015) Controlling weeds with fungi, bacteria and viruses: a review. Frontiers in Plant Science, 6: pp. 659.
20. Lade, B. D., Gogle, D. P., & Nandeshwar, S. B. (2017) Nano Bio Pesticide to constraint plant destructive pests. Journal of Nanomedicine Research, 6(3): pp. 1–9.
21. Nuruzzaman, M., Rahman, M. M., Liu, Y., & Naidu, R. (2016) Nanoencapsulation, Nano-guard for Pesticides: A New window for safe application. Journal of Agricultural and Food Chemistry, 64(7): pp. 1447–1483.
22. Pavela, R., Waffo-Teguo, P., Biais, B., Richard, T., & Mérillon, J.-M. (2017). Vitis vinifera canes, a source of stilbenoids against Spodoptera littoralis larvae. Journal of Pest Science, 90(3): pp. 961–970.
23. Prakash, A., & Rao, J. (1997) Botanical Pesticides in Agriculture. USA: CRC Press Inc., pp. 461.
24. Boyette, C. D., & Hoagland, R. E. (2015) Bioherbicidal potential of Xanthomonas campestris for controlling Conyza canadensis. Biocontrol Science and Technology, 25(2): pp. 229–237.
25. Dubois, C., Arsenault-Labrecque, G., & Pickford, J. (2017) Evaluation of a new biopesticide against angular leaf spot in a commercial operation system. Acta Horticulturae, 1156: pp. 757–764.
26. Eski, A., Demir, . I., Sezen, K., & Demirbag, Z. (2017) A new biopesticide from a local Bacillus thuringiensis var. tenebrionis (Xd3) against alder leaf beetle (Coleoptera: Chrysomelidae). World Journal of Microbiology and Biotechnology, 33(5): pp. 95.
27. Dunham W & Trimmer M, (2018) Biological Products Around the World, Bioproducts Industry Alliance Spring Meeting & International Symposium (www.bpia.org).
28. Moscardi, F., de Souza Lobo, M., de Castro Batista, M. E., Moscardi, L. M., & Szewczyk, B. (2011) Baculovirus pesticides: Present state and future perspectives. In: Microbes and Microbial Technology, Ahmad I., Ahmad F., & Pichtel P. (eds.) Springer New York, USA, pp. 415–445.

29. Radhakrishnan, R., Alqarawi, A. A., & Abd_Allah, E. F. (2018) Bioherbicides: Current knowledge on weed control mechanism. Ecotoxicology and Environmental Safety, 158: pp. 131–138.
30. Shapiro-Ilan, D. I., Gouge, D. H., Piggott, S. J., & Fife, J. P (2006) Application technology and environmental considerations for use of entomopathogenic nematodes in biological control. Biological Control, 38 (1): pp. 124–133.
31. Sosa-Gómez, D. R. (2017) Microbial Control of Soybean Pest Insects and Mites. In: Microbial Control of Insect and Mite Pests: From Theory to Practice (First Edition), L. Lacey (ed), USA: Academic Press, pp. 199–208.