International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319-6734, ISSN (Print): 2319-6726
www.ijesi.org ||Volume 10 Issue 12 Series II || December 2021 || PP 27-31

Biopesticides and Their Mode of Action Against Pests: A Review

Dr. Sanjay Kumar Singh
Assistant Professor, Department of Zoology Manyawar Kanshi Ram Govt. Degree College, Gabhana Aligarh

ABSTRACT
There has been an increase in the use of bio-pesticides around the world due to their eco-friendly and non-toxic methods of pest control. There are a wide variety of biopesticides, including those derived from animals (e.g. nematodes), plants (e.g. Chrysanthemum, Azadirachta), and microorganisms (e.g. Bacillus thuringiensis, Beauveria bassiana, Metarhizium anisopliae, Nucleopolyhedrosis Virus), which include living organisms (natural enemies), their products (e Indigenous technical knowledge (ITK) has proven efficient in controlling pests, however many ITKs have been lost due to the introduction and widespread use of chemical pesticides. For organic farming, they are generally less harmful and more specific than chemical pesticides, and they leave little or no residue.
Crop production will have to rise dramatically over the next two decades in order to keep pace with an expanding human population. This must be done in a way that does not harm the environmental and social benefits of farming. We won't find a 'silver bullet' answer to the looming food crisis. Different innovations are required to fulfill the specific needs of different types of farmers in different regions.Improving pest control is one method of increasing food availability. Integrated Pest Management (IPM) in developed economies, with a focus on India, is examined in this research. When it comes to crop protection, the term "bio pesticides" describes a class of products we use. In particular, we are interested in determining the factors that restrict or promote the commercialization and use of innovative bio pesticides.

I. INTRODUCTION

Entomopathogenic bacteria, fungi, nematodes and viruses are some of the live microorganisms that make up bio-pesticides. They are able to destroy insects and are harmless for the environment without leaving any hazardous residue. There are many advantages to using bio-pesticides over traditional pesticides: they are environmentally benign, cost-effective, and renewable. Chemical pesticides can be replaced by bio-pesticides to boost crop yields of high-quality goods. Agri- alternative technologies like biopesticides are required to tackle the global food crisis menace.

As early as 7000 B.C., humans began cultivating crops, and since then, they've come up with inventive ways to keep insects from eating or otherwise destroying them. It was common practice in some societies to cultivate crops at specific times of the month. Rotating crops, planting tiny, diversified crops, and selecting naturally resistant plants were other early agricultural strategies that indirectly helped to keep bug populations low. Grasshoppers were frightened away by the sounds of people picking bugs off plants by hand. It wasn't long before chemicals were also employed. Middle Easterners employed crushed pyrethrum (a Chrysanthemum species) petals; Romans used sulphur, and the Chinese utilized arsenic. Natural predators like ants were also used by the Chinese to devourunwanted insects.

As a result of new legislation and the growth of insect populations' resistance to synthetic chemical pesticides, crop protection has relied mainly on these chemicals over the past 50 years.

Pesticides based on living microorganisms or natural ingredients are known as bio pesticides. They have been utilized over the world because of their demonstrated ability to control pests. To make things more difficult for the biopesticide business, regulatory mechanisms originally intended for chemical pesticides have been implemented. "Pesticide" is a comprehensive phrase that encompasses a widerange of methods, devices, and chemicals that are used to destroy unwanted plants and animals. It is illegal to employ any of the following types of pest control methods: pesticides for insects, rodenticides for mice and other rodents, nematocides for elongated cylindrical worms, etc. There is a long and notable history of insecticides, perhaps because the number of insects branded "pests" exceeds the number of all other plants and animals combined.

It wasn't until the 1840s that large-scale sulphur applications were used to manage an epidemic of powdery mildew in Britain, a fungus native to North America. Western settlers learnt to defend their potatoes against the Colorado beetle in 1877 by applying water-insoluble pesticides like Paris green. However, pesticides in the nineteenth century were poor and included substances like derria, quassia and tar oil as alternatives. Natural predators had to be introduced to augment them, and vulnerable plants had to be grafted onto more resistant rootstock in some circumstances.

Pesticides were mainly administered by hand until the 1800s, when homeowners started employing big machinery to spray their own gardens. There were no commercial aero planes until after World War I, with the first low-level, well- controlled flights occurring in the 1950s. Large amounts of inert materials (4000 liters per hectare) were employed in the first aerial application of synthetic insecticides (a hectare equals 2.47 acres). When it came to applying pesticides directly to the fields, the amount dropped from 100 to 200 liters per hectare in the 1960s and 1970s to as little as.3 liters per hectare in some circumstances (for example, malathion).

Only 30 pesticides were known to exist at the end of World War II. DDT (dichloride-biphenyl-tricolor-ethane), which had been produced in 1874 but hadn't been identified as an insecticide until 1942, was discovered during World War II due to research conducted during the conflict. Other powerful pesticides, such as chlordane and endrin, quickly followed. Organ phosphorus compounds, the most well-known of which is parathion, were discovered during German research into poison gas. There were a lot of new insecticides out there. Malathion, which was recently utilized in California to combat the med fly, was discovered as a result of additional research and is one of hundreds of organ phosphorus chemicals.

Approximately 900 active chemical pesticides are employed in the production of 40,000 commercial formulations today. Between 1960 and 1980, the use of pesticides doubled, according to the Environmental Protection Agency (EPA). 372 million kilos are utilized in the United States each year, while over 1.8 billion kilogram's are used worldwide.

8.5 billion by 2030, 9.7 billion by 2050, and more than 11 billion by 2100 are the estimates for the world's population (UN. World Population Prospects, 2011). Pest control is essential in agriculture because of the ever-increasing pressure on agriculture to produce more from a smaller amount of land (UN. World Population Prospects, 2011). Approximately 27% to 42% of crop losses are attributed to invertebrates, diseases and weeds, but without crop protection, these losses could grow to as high as 48% to 83%. (Oerke, 2006). To fulfill the increasing demand forfood, a 15–20 times rise in the usage of synthetic pesticides will be necessary (Oerke, 2006) but the excessive World Population Prospects, 2011). It is estimated that between 27 and 42 percent of important crops around the world are affected bypests (insects, diseases, and weeds), but this would climb to 48 to 83 percent without crop protection (Oerke, 2006). As a result, an increase in synthetic pesticide use of 15–20 times (Oerke, 2006) is needed to meet the rising food demand.

In addition to increasing the virulence of a pathogen, many of the microorganisms used in biopesticides have other advantages. Specific isolates of the Trichoderma species, for example, can provide significant plant growth benefits in the absenceof disease and are known to boost plant uptake of soil macro and micro nutrients (Harman, 2011). Plant diseases that target the same crop can be neutralized by entomopathogenic fungi (Ownley et al., 2010).

In 1901, Japanese biologist Shigetane Ishiwata discovered spores of the bacterium Bacillus thuringiensis (BT) from a damaged silkworm and utilized them as abiopesticide for the first time (Chen 2014, Glare et al., 2000). A diseased caterpillar of the flour moth was found ten years later by Ernst Berliner in Thuringen, Germany. Since its classification as Bacillus thuringiensis in 1911, the Bt. pathogen has remained the most extensively used bio pesticide. When Btinitially became commercially available in 1938 as Sporeine, the first commercially available Bt product, the French began using it in the early 1920s as a biological pesticide. In the 1950s, biopesticides became widely used in theUnited States. Because of the widespread use of less expensive but more harmful synthetic chemical insecticides in the second half of the twentieth century, researchand development remained at a low level.

To meet the need, it is vital to boost the manufacturing of high-quality bio-pesticides in Haryana in order to urge farmers, entrepreneurs, and others to use them. Biopesticides currently account for only 2% of all plant protectants used worldwide, although growth has been steadily increasing over the last two decades. There has been a significant increase in the sales of agricultural biologicals. Microbial formulations alone account for about two-thirds of the $2.3 billion in revenue (Cuddeford and Kabaluk 2010).

II. RESEARCH AND DEVELOPMENT IN BIOPESTICIDE

Out of all the bio pesticides used today, microbial bio pesticides constitute the largest group of broad-spectrum bio pesticides, which are pest specific (i.e., do not target non-pest species and are environmentally benign). Over 200 microbial bio pesticides are available in 30 countries affiliated to the Organization for Economic Co-operation and Development (OECD) (Kabaluk and Gazdik 2007). There are 53 microbial bio pesticides registered in the USA, 22 in Canada and 21 in the European Union (EU) (Kiewnick, 2007.

BACTERIAL BIOPESTICIDES

The bacteria that are used as bio pesticides can be divided into four categories: crystalliferous spore formers (such as *Bacillus thuringiensis*); obligate pathogens (such as *Bacillus papillae*); potential pathogens (such as *Serratia marcesens*); and facultative pathogens (such as *Pseudomonas aeruginosa*).Out of these, the spore formers have been most widely adopted for commercial use because of their safety and effectiveness. The most commonly used bacteria are *B. thuringiensis* and *Bacillus sphaericus. B. thuringiensis* is a specific, safe and effective tool for insect control (Roy *et al.*, 2007).

VIRAL BIOPESTICIDES

Over 700 insect-infecting viruses have been isolated, mostly from Lepidoptera (560) followed by Hymenoptera (100), Coleopteran, Diptera and Orthoptera (40) (Khachaturian's 2009). About a dozen of these viruses have been commercialized for use as biopesticides (Table 2). The viruses used for insect control are the DNA-containing baculoviruses (BVs), Nucleopolyhedrosis viruses (NPVs), granuloviruses (GVs), echoviruses, iridoviruses, parvovirus's, polydnaviruses, and poxviruses and the RNA-containing reoviruses, cytoplasm polyhedrosis viruses, nodaviruses, picrona-like viruses and tetra viruses. However, the main categories used in pest management have been NPVs and GVs. These viruses are widely used for control of vegetable and field crop pests globally, and are effective against plant- chewing insects. Their use has had a substantial impact in forest habitats against gypsy moths, pine sawflies, Douglas fir tussock moths and pine caterpillars.

FUNGAL BIO-PESTICIDES

Some of the most widely used species include *Trichoderma harzianum, Trichoderma viridae, Streptomyces griseoviridis, Verticillium chlamydosporium, Beauveria bassiana, Metarhizium anisopilae, Nomuraea rileyi, Paecilomyces farinosus* and *Verticillium lecanii* etc. Many of them have been commercialized globally (Table 2). Trichoderma is a fungicide effective against soil borne diseases such as root rot. It is particularly relevant for dry land crops such as groundnut, black gram, green gram and chickpea, which are susceptible to these diseases. Preparation of *Trichoderma* biopesticide is cheap and requires only basic knowledge of microbiology. This bio- fungicide is recommended as seed treatment, soil application, soil drenching, root dip technique etc for the control of seed and soil borne diseases. Many *Trichoderma* strains, mainly *T. harzianum, T. viride* and *T. virens* (formerly *Gliocladium virens*), have been identified as having potential applications in biological control and a partial list of genera of plant pathogenic fungi affected by *Trichoderma* includes: *Armillaria, Botrytis, Chondrostereum,Colletotrichum, Dematophora, Diaporthe, Endothia, Fulvia, Fusarium, Fusicladium, Helminthosporium, Macrophomina, Monilia, Nectria, Phoma, Phytophthora,Plasmopara, Pseudoperonospora, Pythium, Rhizoctonia, Rhizopus, Sclerotinia, Sclerotium, Venturia, Verticillium,* and wood rot fungi (Singh, 2014). Recent studies also indicate potential use of *Trichoderma* strains ina biotic stress management i.e., drought and salt stress (Shukla *et al.*, 2012).

NEMATODE BIOPESTICIDES-

Another group of microorganisms that can control pests is the entomopathogenic nematodes, which control weevils, gnats, white grubs and various species of the Seaside family (Klein, 1990; Shapiro *al.*, 2002; Grewal, 1990). These fascinating organisms suppress insects in cryptic habitats (such as soil-borne pests and stem borers). Commonly used nematodes in pest management belong to the genera Steinernema and Heterorhabditis, which attack the hosts as infective juveniles (IJs) (Kaya and Gaugler, 1993; Koppenhofer and Kaya, 2002).

PROTOZOAN BIOPESTICIDES-

Although they infect a wide range of pests naturally and induce chronic and debilitating effects that reduce the target pest populations, the use of protozoan pathogens as bio pesticide agents has not been very successful. Protozoa are taxonomically subdivided into several phyla, some of which contain entomogenous species. Microsporan protozoan's have been investigated extensively as possible components of integrated pest management programmes.

OPPORTUNITIES IN INDIA

Harmful impact of chemicals such as higher pesticides residues in food crops, specifically on grains and increasing pest resistance has brought into focus the use of safer and effective alternative such as bio agents/bio pesticides. Moreover, the area under organic crop cultivation is on the rise because of the growing demand of organic food, a result of increasing health consciousness among the people. This indicates that there is huge scope for growth of the bio pesticide sector. Analysts believe that there would be a greater development in the bio pesticides sector (Desai 1997). Due to its rich biodiversity India offers plenty of scope in terms of sources for natural biological control organisms as well as natural plant based pesticides.

The bio pesticide market will continue to grow in future due to increased pest resistance problem and high demand of safe and quality food products. However, there are many challenges that will need to be overcome.Bio pesticides clearly draw attention as safer alternative to manage pest and diseases while posing less risk to human being and the environment. In the US, bio pesticides are monitored by Environmental Protection Agency which supports their registration, sale and distribution under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as well as ensures a "reasonable certainty of no harm" under the Federal Food, Drug, and Cosmetic Act (FFDCA) to provide pesticide residue-free food and feed (Leahy *et al.*, 2014). Most of the times, it is the farmers who are affected by the problems of pesticide resistance and withdrawal of plant protection products, and yet they are policy takers rather than policy makers. Hence, a public- private sector approach to the development, manufacturing and sale of environment friendly alternatives to chemical pesticides for developing countries like India is the need of the day.

SIGNIIFICANCE OF STUDY

The introduction of bio pesticides is an alternative measure to the conventional pest control methods. These bio pesticides are extracted from living organismsusing various processes that do not alter their chemical compositions. Farmers are using synthetic insecticides for controlling the pest on crops. However, repeated applications could lead to the development of insecticide resistance . The potential benefits of using bio-pesticides in agriculture and public health programs are considerable. Bio-pesticides do not have residue problem which is amatter of significant concern for consumers, particularly for fruits and vegetables. When used as a component of IPM, efficacy of bio-pesticides can be equal to the conventional pesticides, especially for crops like fruits, vegetables, nuts and flowers. By combining performance and environmental safety, bio-pesticides perform efficaciously with the flexibility of minimum application restrictions, andsuperior resistance management potential.

The interest in bio-pesticides is based on the advantages associated with the qualityproducts which are-

(i) Inherently less harmful/toxic and environmentally safe.
(ii) Target-specific instead of chemical that have a broad spectrumactivity.
(iii) Often effective in very small quantity,
(iv) Naturally and quickly decomposable,
(v) Low cost in comparison to chemical pesticides.
(vi) Nature of control is preventive instead of curative.
(vii) Usable as a component of IPM.

To emphasize on quality bio-pesticides and residue free farm produces would certainly increase adoption of bio-pesticides by the farmers.

III. CONCLUSION

Uncontrolled use of chemical pesticides has led to a variety of issues, including pesticide residues in food and feed, insecticide resistance and resurgence, environmental contamination, human health risks, and adverse effects on organisms other than the intended targets of the pesticides' intended use. As a result, environmentally friendly pest control methods are desperately needed. Bio- pesticides are an eco-friendly, cost-effective alternative to conventional pesticide- based farming. Quality assurance is necessary for bio-pesticides on the market to perform well in the field. Research on standardization and protocol development for the cultivation of bio-pesticides based on local resources is also needed. Bio- pesticide use in the field is not well understood by farming communities, including storage, application methods, and applicability in the field.

Biopesticides are frequently criticized in the current climate for their inconsistent effectiveness and lack of dependability. Products must meet pre-determined criteria and deliver efficacy within the prescribed circumstances for use, therefore quality control (QC) is of fundamental importance. Biopesticides with strict quality control can help increase agricultural output, yet farmers use chemical insecticides without regard for the consequences. Quality control encompasses not just the finished product, but also the manufacturing and manufacturing processes.

REFERENCES

[1]. Arthurs, SP, Lacey LA, Rosa FDL (2008). Evaluation of granulovirus (PoGV) and *Bacillus thuringiensis* subsp. Kurstaki for control of the potato tuberworm (Lepidoptera: Gelechiidae) in stored tubers. Journal of Economic Entomology; 101: 1540-6.
[2]. Bailey, KL, Boyetchko SM, Langle T. (2010)Social and economic drivers shaping the future of biological control: a Canadian perspectiveon the factors affecting the development and use of microbial biopesticides. Biological Control; 52: 221-9.
[3]. Birch, A. N. E., Begg, G. S., and Squire, G.R. (2011). How agro- ecological research helps to address food security issues under new IPM and pesticide reduction policies for global crop production systems. J. Exp. Bot. 62, 3251–3261
[4]. Chen, R., (2014). Biopesticides: A Formulator's Perspective. http:// news.agropages. com / News/ NewsDetail--- 14156.
[5]. Clouston, A.M., Hill, R.A., Minchin, R., Braithwaite, M., Stewart, A., (2010). A bioassay screening Trichoderma isolates for enhancement of root development in Impatiens Walleriana cuttings. N. Z. Plant Prot. 63,33–38
[6]. Cook, R, Baker K. (1983). The Nature and Practice of Biological Controlof Plant Pathogens. St Paul, MN: Am. Phytopathol. Soc
[7]. Cuddeford, V. and Kabaluk, J.T. (2010). Alternative regulatory models for microbial pesticides. In The Use and Regulation of Microbial Pesticides in RepresentativeJurisdictions Worldwide (Kabaluk *et al.*,eds), pp. 94–98,
[8]. Glare, T.R. and O"Callaghan, M. (2000) *Bacillus thuringiensis*;Biology, Ecology and Safety, Wiley
[9]. Grewal, PS, Ehlers R-U, Shapiro-Ilan DI. (2005). Nematodes as Biological Control Agents. CAB International, Wallingford, UK.
[10]. Klein, MG. (1990). Efficacy against soil- inhabiting insect pests. In: Gaugler R, Kaya HK, editors. Entomopathogenic Nematodes in Biological Control. CRC Press, Boca Raton, FL; p. 195- 214.
[11]. Kaya, HK, Gaugler R. (1993). Entomopathogenic nematodes. Annual Review of Entomology; 38:181-206.

[12]. Koppenhofer, AM, Kaya HK. (2002). Entomopathogenic nematodes and insect pest management. In: Koul 0, Dhaliwal GS, editors. Microbial Biopesticides. Taylor & Francis, London; p. 277-305.
[13]. Kristiofferesen P, Rask AM, Grundy AC, Franken I, Kempenaar C, Raison J (2008). A review of pesticide policies and regulations forurban amenity areas in seven European countries. Weed Research; 48:201-14.
[14]. Khachatourians, GG. (2009). Insecticides, microbials. Applied Microbiology: Agro/ Food; 95-109.
[15]. Köhl, J., Postma J., Nicot P., Ruocco M., Blum B. (2011). Stepwise screening of microorganisms for commercial use in biological control ofplant-pathogenic fungi and bacteria. Biol. Control 57, 1–12.
[16]. Kumar S (2012) Biopesticides: a need for food and environmental safety. J Fertil Pestic 3:e107.
[17]. Keswani, C, Bisen K, Singh V, Sarma B K, Singh HB (2015). Formulation technology of biocontrol agents: Present status and future prospects. Bioformulations: for SustainableAgriculture. pp 35-52.
[18]. Lacey,A. and Siegel.J.P.(2000).Safety and ecotoxicology of entomopathogenic bacteria.In Charles,J.P.,Delecluse,a. and Nielsen-Leroux,C.(eds.),Entomopathogenic bacteria:from laboratory to field condition(p.253-273).D.N.:Kluwer Academic Press.
[19]. Leahy, J, Mendelsohn M, Kough J, Jones R, Berckes N (2014). Biopesticide oversight and registration at the U.S. Environmental Protection Agency. In: Coats (ed.) Biopesticides: state of the art and future opportunities. ACS Symposium Series, American Chemical Society: Washington, DC.
[20]. NAAS, Biopesticides – quality assurance, Policy Paper No. 62, National Academy of Agricultural Sciences, New Delhi, 2013, p. 20.Oerke EC (2006). Crop losses to pests. J Agric Sci144:31–43.
[21]. PMRA. (2008). In: Update on Reduce Risk Pesticides in Canada, RR 2008-01. Health Canada Pest Management Regulatory Agency, Ottawa, Canada. http://www.pmra-arla.gc.ca.
[22]. Roh, J.Y., Choi JY, Li MS, Jin BR, Je YH. (2007). *Bacillus thuringiensis* as a specific, safe, and effective tool for insect pest control. Journal of Microbiology and Biotechnology; 17:547-9.
[23]. Rawat L, Singh Y, Shukla N, Kumar J (2011). Alleviation of the adverse effects ofsalinity stress in wheat (*Triticumaestivum* L.) by seed biopriming withsalinity tolerant isolates of*Trichoderma harzianum*. Plant and soil 347 (1-2), 387.
[24]. Siegel J.P. (2001).The Mammalian safety of Bacillus thuringiensis- based insecticides. Journal of Invertebrate Pathology, 77, 13-21.
[25]. Shapiro-Ilan, DI, Gouge DH, Koppenhofer AM. (2002). Factors affecting commercial success: Case studies in cotton, turf and citrus. In: Gaugler R, editor.Entomopathogenic Nematology. CAB International, New York; p.333-56.
[26]. Shukla, N, Awasthi RP, Rawat L, Kumar J (2012). Biochemical and physiological responses of rice (*Oryza sativa* L.) as influenced by *Trichoderma harzianum* under drought stress. Plant Physiol Biochem 54:78–88.
[27]. Singh, HB, Singh A, Sarma BK, Upadhyay DN (2014). *Trichoderma viride* 2% WP (Strain No. BHU–2953)formulation suppresses tomatowilt caused by *Fusarium oxysporum* f. sp. *lycopersici* and chillidamping–off caused by *Pythium aphanidermatum* effectivelyunderdifferent agroclimatic conditions. Int. J Agri Environ
[28]. Biotechnol7:313–320
[29]. Thakore, Y. (2006). The bio pesticide market for global use. Industrial Biotechnology, 2:194-208. UN. World Population Prospects (2011).
[30]. Van Lenteren, J.C. (2012). The state of commercial augmentative biological control: plenty of natural enemies, but a frustrating lack of uptake. BioControl 57,1–20
[31]. Weindling, R. (1932). *Trichoderma lignorum* as a parasite of other soil