

Biopesticides: A Need for Food and Environmental Safety

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Food and Environmental Safety

The green revolution technology characterized by the use of high yielding varieties, chemical fertilizers, pesticides and water have resulted in a phenomenal growth in agricultural productivity. While the gains have been very impressive, the input intensive agriculture has resulted in some undesirable effects on the environment and the overall sustainability of the farming systems. The use of synthetic chemical pesticides has severely affected both the abiotic and biotic components of the environment. While the former is exemplified by pesticide residues in soil, air, water, food etc., the latter includes phytotoxicity, physiological deformities, diseases, mortality, population changes, genetic disorders, gene erosion, etc. in plants, mammals, avian, insects and other organisms. Entry of chemical pesticides into the food chain coupled with their bioaccumulation triggers several unforeseen consequences. DDT (dichloro-diphenyl-trichloroethane), a modern chemical insecticide, was extensively used in protection of crops, forests and controlling insect-vectors of human diseases. As a contact poison against several arthropods, it was effectively used to combat mosquitoes spreading malaria, typhus and other insect-borne diseases. The indiscriminately used chemical insecticide led to the contamination of water and food sources, poisoning of non-target beneficial insects and development of insect populations resistant to the insecticide [1].

To feed the burgeoning population, we need to produce more food and livelihood opportunities from less per capita arable land and water. Providing ample food for the ever-growing global population is only the first part of the challenge, the second and more important part is to produce this in a safe and sustainable manner. There are an estimated 67,000 pest species that damage agricultural crops [2]. The current pest management strategy relies heavily on synthetic chemical pesticides which causes adverse effects even on the beneficial organisms, pesticide residues in food, feed and fodder, and environmental pollution. Although intensive agriculture provides sufficient food grains, it treads heavily in the environment. Due to the problems of resistance development in pests and withdrawal of some products for either regulatory or commercial reasons, a fewer chemical pesticides are available in the market. Out of the 215 pesticides registered for use in India, 39 have been banned for use or withdrawn from the market (as on September, 2008). The increased public concerns about the potential adverse environmental effects associated with the use of synthetic plant protection and production agrochemicals prompted search for the technologies and products based on biological processes to control the pests.

One of the promising alternatives has been the use of biopesticides. They can replace, at least in part, some hazardous chemical pesticides when incorporated into integrated crop management technology. Although potential and scope of biopesticides and biofertilizers for promoting sustainable agriculture has been known for years, organic farming has emerged now in view of the growing demands for the safe and healthy food, and concerns on environmental pollution. Though the use of chemical inputs in agriculture is indispensable to meet the growing demand for food, feed and fodder, there are opportunities in selected crops and niche areas where biopesticides can be used as a component of integrated pest management (IPM) program. Pest

management in an ecofriendly manner is no longer a dream now. The tools and techniques of molecular biology and biotechnology can facilitate its harnessing in crop plants in a safe and sustainable manner [3].

What is Biopesticide?

Biopesticide is a formulation made from naturally occurring substances that controls pests by non toxic mechanisms and in ecofriendly manner; hence gaining importance all over the world. Biopesticides may be derived from animals (e.g. nematodes), plants (Chrysanthemum, Azadirachta) and micro-organisms (e.g. Bacillus thuringiensis, Trichoderma, nucleopolyhedrosis virus), and include living organisms (natural enemies), their products (phytochemicals, microbial products) or byproducts (semiochemicals) which can be used for the management of pests injurious [4]. The time-tested indigenous technical knowledge (ITK) of using natural materials for the control of pests has been very effective; but due to the introduction and uses of chemical pesticides many ITKs have been forgotten. Biopesticides pose less threat to the environment and human health. They are generally less toxic than chemical pesticides, often target specific, have little or no residual effects and have acceptability for use in organic farming.

Types of Biopesticides

Biopesticides fall into three major categories: plant-incorporated protectants (PIPs), biochemical, and microbial pesticides. Microbial pesticides consist of microorganisms (bacteria, fungi, viruses, or protozoans) as the active-ingredient, and they have been successfully used in controlling insect pests. Though each microbial active-ingredient is relatively specific for its target pest, microbial pesticides can control many different kinds of pests. One of the most widely used microbial pesticides is Bacillus thuringiensis, popularly known as Bt. The bacterium produces crystalline proteins and specifically kills one or a few related insect species. Binding of the Bt crystalline protein to insect gut receptor determines the target insect species. Biochemical pesticides are naturally occurring substances that control pests by non-toxic mechanisms. Such examples are insect sex-pheromones (that interfere with their mating and population build-up), various scented extracts (that attract insect pests to traps) and some vegetable oils [4,5]. 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

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substance that destroys the targeted pest. The pest resistant transgenic plants produce natural biodegradable proteins with no harmful effect on animals and human beings, and thus curtail the use of hazardous pesticides. Application of PIPs may be more useful and economical in the developing countries of the world to help enhance safe food, feed and forage production [6].

Benefits of Biopesticide

The potential benefits of using biopesticides in agriculture and public health programmes are considerable. Biopesticides do not have residue problem which is a matter of significant concern for consumers, particularly for fruits and vegetables. When used as a component of IPM, efficacy of biopesticides can be equal to the conventional pesticides, especially for crops like fruits, vegetables, nuts and flowers. By combining performance and environmental safety, biopesticides perform efficaciously with the flexibility of minimum application restrictions, and superior resistance management potential. The interest in biopesticides is based on the advantages associated with the products which are (i) inherently less harmful and environmentally safe, (ii) target-specific, (iii) often effective in very small quantity, (iv) naturally and quickly decomposable, and (v) usable as a component of IPM.

Market Trends

Biopesticides are used globally for controlling insect pests and diseases. Bioinsecticides, biofungicides and bionematicides are rapidly growing market segments and are expected to boost the demand for biopesticides in future. Globally, there are 175 registered biopesticide active-ingredients and 700 products available in the market. The global market for biopesticides was valued at US \$1.3 billion in 2011, and it is expected to reach US \$3.2 billion by 2017. Increasing demand for residue-free crop produce is one of the key drivers of the biopesticide market. Growing organic food market and easier registration than chemical pesticides are other important driving factors for the growing biopesticide market. North America dominated the global biopesticide market and accounted for about 40% of the global biopesticide demand in 2011. The US biopesticides market is valued at around \$205 million and expected to increase to approximately \$300 million by 2020. European market is estimated nearing \$200 million, and due to the stringent pesticide regulations and increasing demand from organic producers, it is expected to be the fastest growing market. Asian market presents a good opportunity for biopesticides as China and India adopt more biopesticides.

In India, biopesticides represent only 4.2% of the overall pesticide market and is expected to exhibit an impressive annual growth rate of about 10% in the coming years. However, only 15 biopesticides have been registered under the Insecticide Act 1968 (as on 2008). Neem based pesticides, *Bacillus thuringiensis*, Nuclear Polyhedrosis Virus and *Trichoderma* are some of the major biopesticides produced and used in India, while a total of 227 pesticides have been registered so far.

Policy Issues

For efficient and effective utilization of biopesticides, several technological and policy gaps have been identified which need to be addressed properly. Killing effects may not be as fast compared to that of the chemical pesticides, and shelf life is often shorter. Inconsistency in efficacy, degree of stringency of regulation, quality control, scientifically sound use packages, and well defined role in IPM are some of the aspects which need consideration and further refinement. Policy

measures need to be strengthened in order to reduce excessive use of chemical pesticides and promote the use of biopesticides.

In USA, Environmental Protection Agency (EPA) encourages development and use of biopesticides. Biopesticides and Pollution Prevention Division (under the Pesticide Programs) were established in 1994 to facilitate registration of biopesticides. Since biopesticides tend to pose fewer risks than chemical pesticides, EPA generally requires much less data to register a biopesticide than to register a conventional pesticide. Data about the composition, toxicity, degradation, and other characteristics of the pesticide is required to be submitted by the registrants to EPA to make sure that a pesticide is safe. Often less than a year is required to register a new biopesticide, compared with more than three years for a chemical pesticide. EPA conducts rigorous reviews to ensure that pesticides do not have adverse effects on human health or the environment.

In India, Ministry of Agriculture regulates the use of pesticides under the Insecticides Act 1968, recently replaced by the Pesticides Management Bill 2008. Approval for the use of pesticides is given by a Registration Committee, while Ministry of Health and Family Welfare monitors and regulates pesticides residue levels in food. Indian Government recently adopted IPM to promote biologically diverse biopesticides as an alternative to 'persistent organic pollutant' pesticides. Recognizing the ill effects of chemical pesticides such as development of pest resistance, pest resurgence, outbreak of secondary pests, pesticide residues in food, feed, fodder, soil, air and water resulting in human health hazards and ecological imbalances, most of the countries throughout the world have also amended their policies to minimize the use of chemical pesticides and promote use of the biopesticides.

Editor's Remarks

Biopesticides clearly have a potential role to play in development of IPM strategies. More rational approaches would be required to popularize biopesticides as one of the important inputs for safe and sustainable agriculture. Hopefully, the short-term profits from chemical pesticides will not determine the fate of biopesticides. However, training on production and quality control to manufacturers, and organizational training to extension workers and farmers to popularize biopesticides may be essential for better adoption of the technology. As environmental safety is of global concern, we need to create awareness among the common men to switch-over to biopesticides for their pest management requirements.

The Journal of Biofertilizers and Biopesticides, an open access international peer-reviewed journal, plays an important role towards the advancement of our understanding about the biological agents and their products to be used as biofertilizers and biopesticides for the food and environmental safety. The efforts made by the OMICS Publishing Group, USA, towards publishing open access journals, organizing international conferences on such pertinent issues are appreciable and will generate awareness among the researchers, farmers, environmentalists, policy makers and the general public.

The views expressed here belong to the authors only. It may not necessarily be the views of the institution/organization, the author is associated with.

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