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Editorial Open Access

Biopesticide: An Environment Friendly Pest Management Strategy

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Editorial

The Food and Agricultural Organization (FAO) of the United Nations has forecasted the need to increase world food production by 70% in order to keep pace with the growing demand of food due to the ever-growing global population [1]. Increasing food production is the primary objective of all the countries, as the global population is expected to reach ≈10 billion by 2050. Moreover, to feed the burgeoning global population, we need to produce more food and livelihood opportunities from reducing per capita arable land and water. To meet the food, feed and fodder requirements we have deployed intensive agriculture which uses green revolution technology. The green revolution technology has been characterized by excessive use of high yielding varieties, chemical fertilizers, pesticides and irrigation water. While the gain in agricultural production has been very impressive, the input intensive agriculture has resulted in several undesirable effects on the environment and the overall sustainability of the farming systems. Use of synthetic 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 plant, mammal, avian, insect and other organisms. Entry of chemical pesticides into food chain and their bioaccumulation triggers several unforeseen consequences. However, in the conventional agriculture most of the weeds, pests, insects and diseases were controlled using natural and sustainable practices such as cultural, mechanical, and physical control strategies. Environmental safety and agricultural sustainability are equally important for survival on the Earth. This is where biopesticides come into the picture, which may be considered as one of the components required to protect the environment and render sustainability to the agricultural production.

Biopesticides are made from naturally occurring substances that controls pests by non-toxic mechanisms and in ecofriendly manner. They may be derived from animals (e.g. nematodes), plants (*Chrysanthemum, Azadirachta*) and microorganisms (e.g. *Bacillus thuringiensis*, Trichoderma, Nucleopolyhedrosis virus), and include living organisms (natural enemies), their products (phytochemicals, microbial products) or byproducts (semiochemicals) [2]. Hence 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. Biopesticides generally fall into three major categories: (i) microbial, (ii) biochemical, and (iii) plant-incorporated protectants (PIPs) [3].

While microbial pesticides may consist of bacteria, fungi, viruses, or protozoans as active-ingredient, biochemical pesticides are naturally occurring substances that control pests by non-toxic mechanisms. 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. Examples of biochemical pesticides include 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 [2,4]. PIPs include substances that are produced naturally by genetically modified plants. Such examples are Bt transgenic crop plants. Gene for protease inhibitor, lectines, chitinase etc. has also been tested for their incorporation into plant genome so that the transgenic plant synthesizes naturally the substance that destroys the targeted pest. Genetically Modified (GM) plants produce biodegradable proteins harmless to non-target animals and human beings, and thus curtail use of hazardous chemical 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 [5].

To feed the ever-growing global population, we need to produce more and more food from less per capita arable land and available water. Providing ample foods is only the first part of challenge, the second and more important challenge is to produce them in a safe and sustainable manner [6]. Since most of the cultivated crops have reached their yield plateau, protection of crops to harvest maximum and store them safe are important to meet the increasing food demands and to attain global food security. A large number of pests damage agricultural crops and a significant portion of agricultural inputs is required to protect the crops from them. Pesticides have been extensively used in the intensive agriculture to reduce yield losses and maintain the product quality. This extensive use of synthetic pesticides has certainly provided protection to the crops; however it has also raised concerns about pesticide residues in the food and the environment [1]. Chemical pesticides adversely affect beneficial organisms, leave harmful residues in food, feed and fodder, and causes environmental pollutions. Human exposure to pesticides occurs primarily through contaminated food, feed and drinking water. Their adverse effects depend on toxicity of pesticides, method of application, the dosage applied, their adsorption on soil colloids, the weather conditions prevailing after their application, and how long the pesticides persist in the environment. Hence, the need of the day is to produce maximum from the decreasing availability of natural resources without adversely affecting the environment.

Benefits of Biopesticides

Integrated Crop Management (ICM) is a pragmatic approach to maintain intricate balance between the environmental safety and agricultural productivity with sustainability being important issue. One of the important objectives of ICM is reducing external inputs, such as inorganic fertilizers, pesticides and fuel by means of farm produced

substitutes. Although complete replacement of these inputs is not possible without significant loss of yields, but partial substitution of the inputs can be achieved by the use of natural resources. In recent decades, the focus on crop production has shifted from yield to quality and safety. Evidences suggest that biopesticide is an important component for promoting sustainable agriculture, hence it has gained lots of interest in the last decade particularly in view of the growing demands for organic foods.

Environmental issues

Although green revolution technology has resulted in a phenomenal growth in agricultural productivity, it treads heavily in the environment. Continuous use of chemical pesticides has severely affected the environment. Pesticide residues in food items and their bioaccumulation in the body triggers several health hazards. Like any other pesticides, DDT (dichloro-diphenyl-trichloroethane) was extensively used in protection of crops, forests and controlling insect-vectors of human diseases. As a contact poison 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 [6].

There are an estimated 67,000 agricultural pest species that damage crops [7]. The current pest management strategy relies heavily on chemical pesticides which cause adverse effects even on beneficial organisms, leave pesticide residues in food, feed and fodder, and increase environmental pollutions. Although intensive agriculture has provided sufficient food grain production so far, it has several environmental consequences. Due to the problems of resistance development in pests and withdrawal of some products for either regulatory or commercial reasons, only 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 [3]. There are rising concerns for the loss of biodiversity and endangered species, set against the requirement to increase agricultural production without excessive reliance on chemical pesticides. Development of biopesticides has largely followed a chemical pesticide model that does not exploit fully the favorable biological properties of the biological agents. While there is commercial pressure from the manufacturing side to develop products, based on a single strain that are broad spectrum in order to control a range of pests on different crops and may not be endemic to the areas of application; the environmentalists prefer narrow spectrum products based on the strains from the area of use. To reconcile these divergent demands, biopesticides in the market have been maintained at minimal negative impact, if any, on the environment. The increased public concerns about the potential adverse environmental effects associated with the use of synthetic pesticides prompted search for the products based on natural resources.

Policy issues

Biopesticides are used globally to control insect pests and diseases. Bioinsecticides, biofungicides and bionematicides are rapidly growing market segments and their demand is expected to boost further in the near future. Globally, there are 175 registered biopesticide active-ingredients and more than 700 products available in the market. The global market for biopesticides has been valued at US $2.3 billion, and it is expected to reach US $5.2 billion by 2020. However, biopesticides represent only 1% of the global market for agrochemicals. There are several reasons why adoption of biopesticides has been higher in the US than elsewhere [8]. Increasing demand for pesticide residue-free crop produce is one of the key drivers of the biopesticide market. Growing organic food market and easier registration than synthetic chemical pesticides are other important driving factors.

Identifying the ill effects of chemical pesticides, pesticide resistance, pest resurgence, outbreak of secondary pests, pesticide residues in crop produce, soil, air and water resulting in human health hazards and ecological imbalances, most of the countries have amended their policies to ensure minimal use of chemical pesticides and promote the use of biopesticides. However, biopesticides are still under the regulatory system originally developed for chemical pesticides. This creates market entry barrier by imposing burdensome costs on biopesticide industry. There are several technological and policy gaps in effective utilization of biopesticides which need to be addressed properly. Policy measures need to be strengthened in order to minimize use of chemical pesticides and to promote the use of biopesticides. In addition, there are certain technical difficulties in making biopesticides more effective and applicable.

Generally biopesticide application is not complicated, however application of the biopesticides may require training and knowledge about pests/pathogens against which they can be applied successfully. As with any pesticide, appropriate time of application is essential to ensure efficacy of the biopesticide. The challenging task to develop a balance between the broadly defined costs and benefits of biopesticides compared with the synthetic pesticides. The newer biopesticides may bring with them new regulatory and economic challenges that must be addressed jointly by the social and natural scientists, policy makers and the industry. One of the major obstacles in promoting biopesticides is the lack of profile which again reflects weakness of the policy network. Relative immaturity of the policy network, limited resources and capabilities, lack of trust between regulators and producers are some of the serious issues. A better understanding of the mode of action of the biopesticide, their effects, regulatory issues that arise on their adoption may help to raise their profile among the public and policy-makers.

Recent advancements and future prospects

Biopesticide is a promising alternative to chemical pesticide. Biopesticides can replace at least in part some of the hazardous chemical pesticides when incorporated into ICM practices. Although potential of biopesticides and biofertilizers for promoting sustainable agriculture has been known for years, their demands have increased now in view of the organic farming to produce safe and healthy food. Pest management in an ecofriendly manner is no longer a dream now. The tools and techniques of molecular biology and biotechnology facilitate producing biopesticides in crop plants itself in a safe and sustainable manner [9]. In addition to the continuous search for new biomolecules and improving efficiency of the known biopesticides, recombinant DNA technology is also being used for enhancing efficacy of biopesticides [1]. Better understanding of genes from microorganisms and crop plants has enabled isolation of genes effective against particular pest, and they are being deployed to control insect pests and diseases. Fusion proteins are also being designed to develop next-generation biopesticides. This technology allows selected toxins (not toxic to higher animals) to be combined with a carrier protein which makes them toxic to insect pests when consumed orally, while they were effective only when injected into a prey by a predator [10]. The fusion protein may be produced as a recombinant protein in

microbial system, which can be scaled up for industrial production and commercial formulations. Several other innovative approaches are being applied to develop biopesticides as effective, efficient and acceptable pest control measure.

Editor's Remarks

Biopesticide is a potential tool to be utilized for environmental safety. More rational approaches would be required to popularize biopesticide as one of the important inputs for safe and sustainable agriculture. Training on production and quality control to manufacturers, organizational training to extension workers and farmers to popularize biopesticides would be essential for better adoption of biopesticides. As environmental safety is a global issue, we need to create awareness among the common men to switch-over to biopesticides for their pest management requirements. Biopesticides are expected to provide predictable performance, and they must do so in an economically viable manner for their better acceptability and adaptability. To be readily acceptable by the end users, biopesticides must be efficient enough in controlling the targeted pests. Deployed properly, biopesticides have tremendous potential to bring sustainability to agriculture and environmental safety.

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

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