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Biopesticides: Present Status and the Future Prospects

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Agriculture is adversely affected by numerous pests like bacteria, fungi, weeds and insects, leading to reduced yield and poor quality of the produce [1]. Since 1960s, the most common method for pest control has been the intensive use of synthetic pesticides. Such pesticide was adopted in 1940s with the use of dichloro-diphenyl-trichloroethane (DDT), followed by other organophosphate and carbamate pesticides [2]. Thereafter, Green Revolution technology of crop production could increase food production in developing countries through the intensive use of inputs like chemical fertilizers and pesticides etc. Albeit, the use of the agrochemicals helped a lot in increasing agricultural productivity; they have caused adverse effects on soil health, water quality, produce quality and developed problems like insect resistance, genetic variation in plants, toxic residues food and feed. Moreover dependence on chemical pesticides and their indiscriminate use caused several detrimental effects on the environment. Recognizing the ill effects of the agrochemicals such as pesticide resistance, pest resurgence, outbreak of secondary pests, pesticide residues in the produce, soil, air and water [3], it has become important now to develop alternatives of these synthetic agro-inputs. The need of the day is to produce maximum from the diminishing natural resources and protect the produce from post-harvest loses without adversely affecting the environment. Use of biofertilizers and biopesticides can play major role in dealing with these challenges in a sustainable manner.

Biopesticides and biofertilizers, the naturally occurring formulations made from the substances that control pests by non toxic mechanisms and in ecofriendly manner, are not newer technologies. They have been used in various forms since human civilization. Biopesticides being a living organisms (natural enemies) or products there of pose less threat to the environment and to human health, hence can be used for the management of pests. One of the most widely used microbial biopesticides is *Bacillus thuringiensis,* popularly known as Bt. Potential benefits of the use of biopesticides to agriculture and public health programmes are considerable.

Advantages of Biopesticide

Biopesticide is gaining interest because of its advantages associated with the environmental safety, target-specificity, efficacy, biodegradability and suitability in the integrated pest management (IPM) programs. Thus, biopesticide is one of the promising alternatives to manage environmental pollutions. Though potential application of biopesticides in environmental safety is well known, it has gained interest in view of the growing demands for organic food. Although use of agrochemicals is indispensable to meet the ever growing demands of food, feed and fodder, opportunities do exist in selected crops and niche areas where biopesticides can be used as a component of IPM. Through wider application of biopesticides in agriculture and health programs, environmental safety can be beneficially affected.

Present Status

Presently, biopesticides cover only 2% of the plant protectants used globally; however its growth rate shows an increasing trend in past two decades. Global production of biopesticides has been estimated to be over 3,000 tons per year, which is increasing rapidly. Increasing demand of residue-free agricultural produce, growing organic food market and easier registration than chemical pesticides are some of the key drivers of the biopesticide market. Globally, the use of biopesticides is increasing steadily by 10% every year. About 90% of the microbial biopesticides are derived from just one entomopathogenic bacterium, *Bacillus thuringiensis*. More than 200 products are being sold in the US market, compared to only 60 comparable products in the EU. More than 225 microbial biopesticides are manufactured in 30 OECD countries [4]. The NAFTA countries (USA, Canada, and Mexico) use about 45% of the biopesticides sold, while Asia lacks behind with the use of only 5% of biopesticides sold world over [5].

Most of the countries have amended their policies to minimize the use of chemical pesticides and promote the use of biopesticides; however biopesticides are still largely regulated by the system originally designed for chemical pesticides. This has created market entry barriers by imposing burdensome costs on the biopesticide industry [6]. Although for effective utilization of biopesticides several technological and policy gaps have been identified, they need to be addressed properly at the country level. Policy measures need to be strengthened in order to reduce excessive use of chemical pesticides and to promote the use of biopesticides.

One of the major obstacles in promoting biopesticides as alternative to chemical pesticides is the lack of profile of biopesticide, which reflects weakness of the supporting policy network. Relative immaturity of the policy network, limited resources and capabilities, and lack of trust between regulators and producers are some of the serious problems. Better understanding of the mode of action of biopesticides, their effects and regulatory issues that arise in their adoption may help further to raise their profile among the public, policy-makers and hence enable them to realize their contributions to sustainability. Since the environmental safety is a global concern, we need to create awareness among the farmers, manufacturers, government agencies, policy makers and the common men to switch-over to biopesticides for the pest management requirements.

Recent Advances

The science of biopesticide is still considered to be young and evolving. In-depth research is needed in many areas such as production, formulation, delivery and commercialization of the products. Some of the biopesticides, currently under development, may prove to be excellent alternatives to the chemical pesticides. Many of them are based on the locally available plants like *beshram, neem, garlic, triphala, pinus kesia* etc. which can be easily processed and made available to

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the farmers to improve biopesticide consumption. In addition to the continuous search for new biomolecules and improving efficiency of the known biopesticides, recombinant DNA technology is also being deployed for enhancing efficacy of biopesticides. Novel fusion proteins are being designed to develop next-generation biopesticides. The technology allows a toxin (not toxic to higher animals) to be combined with a carrier protein which makes it toxic to insect pests when consumed orally, while it was toxic only when injected into a target prey by a predator [7]. 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 also being applied to develop biopesticides as effective, efficient and acceptable pest control measures.

Future Prospects

Biopesticides are attracting global attention as safer strategy to manage pest populations such as weeds, plant pathogens and insects while posing less risk to human being and the environment. In the US, biopesticides are monitored by Environmental Protection Agency which supports their registration based on the findings of "no unreasonable adverse effects" to human and the environment to permit their 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 [8]. 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 is the need of the day.

Research in production, formulation and delivery may greatly assist in commercialization of biopesticides. More research is needed towards integrating biological agents into production system, improving capability of developing countries to manufacture and use biopesticides. At the same time, it is also required to encourage public funded programmes, commercial investors and pesticide companies to take up biopesticide enterprises. Equally important is the development of strict regulatory mechanisms to maintain the quality and availability of the biopesticides at affordable cost in the developing countries. Thus, various aspects of biopesticides covering the current status, constraints, prospects and regulatory network towards their effective utilization for the benefit of human kind need to be reviewed regularly.

Concluding Remarks

The world production and utilization of biopesticides are increasing at a rapid pace. The interest in organic farming and pesticide residue-free agricultural produce would certainly warrant increased adoption of biopesticides by the farmers. 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 this technology. As environmental safety is a global concern, we need to create awareness among the farmers, manufacturers, government agencies, policy makers and the common men to switch-over to biopesticides for pest management requirements. It is also believed that biological pesticides may be less vulnerable to genetic variations in plant populations that cause problems related to pesticide resistance. If deployed appropriately, biopesticides have potential to bring sustainability to global agriculture for food and feed security.

The views expressed here are those of the authors only. These may not necessarily be the views of the institution/organization the authors are associated with.

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