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Biopesticide: The Need for Present and Future Agriculture

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Abstract—*Bio-pesticides are eco friendly pesticides which are obtained from naturally occurring substances (biochemicals), microbes and plants. Not all natural products are biopesticides. Some are chemical pesticides if they act on nervous system of the pest. 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 to chemicals, reduces water pollution through fertilizer runoff, reduces number of applications, causes less harm to beneficial pests, biodegradable, and provides better nutritional quality. The total world production of biopesticides is over 3,000 tons/yr, which is increasing at a rapid rate. India has a vast potential for biopesticides. However, its adoption by farmers in India has to be motivated for maximizing gains. Some bio-pesticides currently being developed may be excellent alternatives to chemical pesticides. Also in India, there are many locally available plants like neem, garlic, triphala, Pinus kesia etc which can be easily processed and increase the biopesticide consumption in India. However, in India, some of the biopesticides like Bt, NPV, neem based pesticides, Trichoderma etc. have already been registered and are being practiced. Through my paper, I would like to highlight role of biopesticides in agriculture and potential biopesticides available in India. Also, the establishment of biopesticide units in rural areas, where such plants are available, will also provide employment to the dwellers. 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.*

Keywords: *biopesticide, environment, trichoderma*

1. INTRODUCTION

The sharp increase in the use of chemical pesticide in India in recent years has resulted in severe implication in the development of insecticidal resistance in key pest species, pesticide residue in food chain, degradation in the quality of ecosystem and human health. Microbar's such as viruses, bacteria, fungi, protozoa, nematodes and plant products are the major biopesticides that were studied mostly to develop alternatives to chemicals. In India, biopesticide science is not a new tool and is as old as human civilization back to prehistoric days. Though biopesticides cover only about 1% of the total plant protection products globally, their number and the growth rate have been showing an increasing trend in the past two decades. The biopesticides offer desirable alternative to using synthetic chemicals in agricultural system, where protection of the environment and conservation of beneficial organisms are considered as most important part. Biopesticides are less toxic and generally affect only the target pest. These can also save our environment and natural fauna. Increasing use of agro-chemicals, higher production cost and deteriorating ecosystem health have advocated the need to change traditional and external input use agriculture towards safe and sustainable organic production. Moreover, environmental pollution and food safety due to chemical contamination has become a great concern world wide. Food and Agriculture Organization (FAO) proposed "Integrated Pest Management Plan of Action in recognition with the importance of integrating all possible and safe efforts for control of insect pests (Atwal, 1996). Integrated Pest Management is an approach to keeping pest populations below a level causing economic loss, through the judicious and compatible use of two or more of several possible control measures: biological, cultural, biology-based, genetic, mechanical and chemical (Facknath, 1997).

2. WHAT IS BIOPESTICIDE?

Biopesticide is a formulation made from naturally occurring substances that controls pests by non toxic mechanisms and in eco-friendly 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. 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.

3. 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. 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 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.

Bacteria: Microbial pesticides based on the soil-borne bacterium *Bacillus thuringiensis* (Bt) are among the most widely used groups of biopesticides. Formulations based on Bt subsp. *kurstaki* and Bt subsp. *aizawai* have been found to be effective against several lepidopteran pests either alone or in combination with other biopesticides or biocontrol agents on vegetables. One of the most successful examples of microbial biopesticide use is in the management of diamondback moth (*Plutella xylostella*) in tropical Asia and Africa. Diamondback moth is the most destructive insect pest on vegetable brassicas in the world, sometimes causing more than 90 percent crop losses (Iqbal *et al.*, 1996).

Viruses: Entomopathogenic viruses, especially nucleopolyhedrovirus (NPV) and granulovirus (GV), also are known to be effective against various insect pests on vegetables. *Helicoverpa armigera* NPV (HaNPV), *Spodoptera litura* NPV (SlNPV), and *S. exigua* NPV (SeNPV) already have been commercialized and are widely used against tomato fruit worm (*Helicoverpa armigera*), common army worm (*Spodoptera litura*) and beet army worm (*S. exigua*), respectively (Vinod Kumari and Singh, 2009).

Baculoviruses: These are target specific viruses which can infect and destroy a number of important plant pests. They are particularly effective against the lepidopterous pests of cotton, rice and vegetables. Their large-scale production poses certain difficulties, so their use has been limited to small areas. They are not available commercially in India, but are being produced on a small scale by various IPM centres and state agricultural departments.

Trichoderma: Trichoderma is a fungicide effective against soil born diseases such as root rot. It is particularly relevant for dryland 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.

Trichogramma: Trichogramma are minute wasps which are exclusively egg-parasites. They lay eggs in the eggs of various lepidopteran pests. After hatching, the Trichogramma larvae feed on and destroy the host egg. Trichogramma is particularly effective against lepidopteran pests like the sugarcane internode borer, pink bollworm and sooted bollworms in cotton and stem borers in rice. They are also used against vegetable and fruit pests. Trichogramma is the most popular biocontrol agent in India, mainly because it kills the pest in the egg stage, ensuring that the parasite is destroyed before any damage is done to the crop. Trichogramma eggs have to be used within a short period (before the eggs hatch). This limits their production and marketing on a large scale, and is also the reason why Trichogramma is not sold through dealers and shopkeepers.

Neem: Derived from the neem tree *(Azadirachta indica)*, this contains several chemicals, including 'azadirachtin', which affects the reproductive and digestive process of a number of important pests. Recent research carried out in India and abroad has led to the development of effective formulations of neem, which are being commercially produced. As neem is non-toxic to birds and mammals and is non-carcinogenic, its demand is likely to increase. However, the present demand is very small. Although more than 100 firms are registered to produce neem based pesticides in India, only a handful are actually producing it. Furthermore, very little of the production is sold locally, most being for export markets.

Sex pheromones: Insect sex pheromones are biochemical pesticides and have long been used as monitoring and mass-trapping tools in IPM strategies. Several sex pheromone lures including insects like tomato fruit worm, common army worm, beet army worm, legume pod borer and cucumber moth

(*Diaphania indica*) are commercially available. A synthetic sex pheromone for legume pod borer consisting of (E, E)-10, 12-hexadecadienal, (E,E)-10,12-hexadecadienol, and (E)-10-hexadecenal (Downham *et al.*, 2003, 2004) was developed and attracted male moths in Benin and Ghana, while (E,E)-10,12-hexadecadienal alone was most effective in Burkina Faso (Downham, 2006).

Aggregation pheromones: Attempts are underway to develop an IPM strategy based on aggregation pheromones for managing the striped flea beetle (*Phyllotreta striolata*) on vegetable brassicas. Actively feeding striped flea beetle males produce an aggregation pheromone. Seven male-specific sesquiterpenes have been identified from the aggregation pheromone of striped flea beetle.

***Plant volatiles*:** Certain secondary metabolites in plants act as deterrents for generalist feeders, and attractants for specialist feeders. For instance, glucosinolates and their metabolites act as attractants and stimulants for specialist brassica feeders such as flea beetles (*Phyllotreta* spp.) (Chew, 1988; Louda and Mole, 1991).

4. 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.

5. POTENTIAL FOR BIOPESTICIDES IN INDIA

About 80,000 tons of pesticides are used in agriculture in India annually (Srinivasan, 1997), mostly in cotton and rice. While cotton is planted on about 5% of the total cultivable area (on about 8 million hectares out of a total of 170 million), it accounts for about 45% of pesticide application (Dhaliwal and Pathak, 1993). Rice accounts for another 23%. Vegetables and fruit also account for a significant proportion. It is clear that the excessive use of chemical pesticides in agriculture is a serious cause of concern. It is, therefore, important that alternative, environmentally friendly methods of plant protection are adopted, such as integrated pest management (IPM) techniques, including the use of biopesticides.

6. CONCLUSIONS

India's rich bio-diversity is an ace factor, always providing a wide source of biopesticides which can be effectively used in agriculture at a large scale. Also increasing health consciousness of Indian citizens has 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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