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BIOPESTICIDES: AN EFFECTIVE TOOL FOR INSECT PEST MANAGEMENT AND CURRENT SCENARIO IN INDIA

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Abstract: *Agricultural crops are vulnerable to attack number of pests like bacteria, fungi, weed and insects, leading to reduced yield and poor quality of the produce. Synthetic pesticides are highly effective in pest control because only they act on a broad host range but their negative impact 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 farmer 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. Biopesticides are considered to be the best alternative to synthetic pesticides that are highly effective, target specific and reduce environmental risks. These factors led to its application in pest management program instead of chemical pesticides throughout the world. Biopesticides are derived from animals, plants and other natural materials such as fungi, bacteria, algae, viruses, nematodes and protozoa. The advance research and development in the field of biopesticides applications greatly reduce the environmental pollution caused by the chemical synthetic insecticides residues and promotes sustainable development of agriculture. Since the advent of biopesticides, a large number of products have been registered and released, some of which have played a leading role in the agro-market in India. In India several bio-pesticides currently being developed may be excellent alternatives to chemical pesticides. There are many locally available plants like neem, garlic, triphala, pinuskesia, cymbopogan etc., which can be easily processed and used for pest management. However, in India, some other microbial biopesticides like Bt, NPV, Trichoderma, Pseudomonas etc. have already been registered and are being practiced by farmers. The development of biopesticides has prompted to replace the chemical pesticide in pest management for sustainable crop production.*

Keywords: *Biopesticides, Synthetic pesticide, Environment, Bt, NPV.*

Introduction: Agriculture is the backbone of the Indian economy and contributes 18% to the GDP. It ensuring food security for more than 1.26 billion Indian populations with diminishing cultivable land resource is a herculean task. Pesticides have been the most effective weapons and play vital role in crop protection against agricultural insect-pests. The green revolution technology has been characterized by excessive use of high yielding varieties, chemical fertilizers, pesticides and irrigation water. After green revolution agricultural production has been very impressive but the indiscriminate use of chemical fertilizers and pesticides has resulted in several undesirable effects on the environment and the overall sustainability of the farming systems. However, indiscriminate use of synthetic chemical pesticides over the last four decades has adversely affected human health, non target organisms and environment, and has also enhanced development of pesticide resistance among pest species [1, 2]. 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. Therefore, it is very urgent to identify alternatives to chemical pesticides for plant protection without sacrificing the productivity and profitability of agriculture. Due to the side effects of chemical pesticides, sustainable crop production through eco-friendly management is essentially required in the present scenario. 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. Due to these factors, farmers adopted biopesticides which are environmentally friendly and reduced frequently application of synthetic insecticides for pest management [3]. Nowadays, a lot of biopesticides have been developed from microorganisms (bacteria, fungi, viruses, etc.), plant, animal derived products (pheromones, hormones, insect-specific toxins, etc.) and genetically modified organisms and used worldwide for insect pest management [4, 5]. This article summarizes the current scenario of biopesticides usages in India and role of biopesticides in integrated pest management.

What is Biopesticides?: Biopesticides define according to the US Environmental Protection Agency (USEPA), biopesticides are pesticides derived from natural materials such as animals, plants, bacteria, and minerals. Biopesticides also include living organisms that destroy agricultural pests. Biochemical pesticides are chemicals either extracted from natural sources or synthesized to have the same structure and function as the naturally occurring chemicals. Biochemical pesticides are distinguished from conventional pesticides both by their structure (source) and mode of action (mechanism by which they kill or control pests) [6]. In general term, Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. For example, canola oil and baking soda have pesticidal applications and are considered biopesticides.

Types of Biopesticides: Biopesticides are an important ingredient of Integrated Pest Management (IPM) packages due to their capability in maintaining the natural diversity without the use of any artificial or synthetic residues. The origin of Biopesticides can be microbial (bacteria, fungi or virus), herbal (plant extracts) or genetically modified plants (GM). Beauveria spp., Trichoderma spp., and Bacillus spp., are some of the microbial biopesticides. Products made out of garlic and neem is used extensively as herbal biopesticides. The EPA separates biopesticides into three major classes based on the type of active ingredient used, namely, biochemical, plant-incorporated protectants, and microbial pesticides [7].

Microbial Pesticides: These pesticides originate from micro-organisms such as bacteria, fungi or other protozoan groups. These are mostly target-specific organisms that are aimed at killing one or a group of pests (e.g., a bacterium, fungus, virus or protozoan).

Biochemical Pesticides: These herbal-based substances are naturally produced by a plant or an organism. They are non-toxic and biodegradable. They help the plant in counter-attacking its pests or producing chemicals that would prevent pest attack on the plant. Examples are fatty acids, pheromones.

Plant Incorporated Protectants: These are genetically modified materials produced by scientists by modifying a protein and introduced into the plant so that it produces its own pesticide. For example, gene for the Bt pesticidal protein, and introduce the gene into the plant's own genetic material. Then the plant, instead of the Bt bacterium, manufactures the substance that destroys the pest.

Status of Biopesticides in India: The Indian crop protection market is dominated by Insecticides, which form almost 60% of domestic crop protection chemicals market. The major applications are found in rice and cotton crops. Fungicides and Herbicides are the largest growing segments accounting for 18% and 16% respectively of total crop protection chemicals market respectively. As the weeds grow in damp and warm weather and die in cold seasons, the sale of herbicides is seasonal. Rice and wheat crops are the major application areas for herbicides. Increasing labor costs and labor shortage are key growth drivers for herbicides. The fungicides find application in fruits, vegetables and rice. The key growth drivers for fungicides include a shift in agriculture from cash crops to fruits and vegetables and government support for exports of fruits and vegetables. Bio-pesticides include all biological materials organisms, which can be used to control pests. Currently bio- pesticides constitute

only 3% of Indian crop protection market; however there are significant growth opportunities for this product segment due to increasing concerns of safety and toxicity of pesticides, stringent regulations and government support [8, 9].

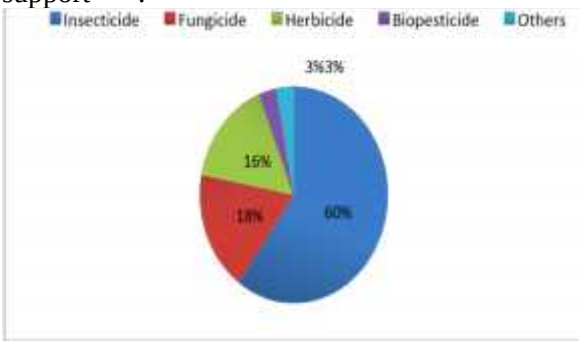

Fig.1- Pesticide used in India.

Currently, in India more than 240 pesticides are registered under section 9(3) of the Insecticide Act, 1968, for use and technical grade pesticides are manufactured indigenously. However, biopesticides may represent about 4.2% of the overall pesticides market in India [10] and is expected to increase drastically in coming years. Globally, biopesticides production is 4.5% and in USA it is 6%, whereas in India, it accounts only 3% of the total chemical pesticides production. Presently, only 12 types of biopesticides formulations are registered in India, some major biopesticides produced and used namely Neem based pesticides, *Bacillus thuringensis*, NPV and *Trichoderma* are the major biopesticides registered under the Insecticide Act, 1968 in India. Whereas more than 230 synthetics are registered for use as chemical pesticides.

Table 1: Biopesticides registered as insecticides Act, 1968.

1. Bacillus thuringiensis var. israelensis
2. Bacillus thuringiensis var. kurstaki
3. Bacillus thuringiensis var. galleriae
4. Bacillus sphaericus
5. Trichoderma viride
6. Trichoderma harzianum
7. Pseudomonas fluoresens
8. Beauveria bassiana
9. NPV of Helicoverpa armigera
10. NPV of Spodoptera litura
11. Neem based pesticides
12. Cymbopogan

In Indian, there is a needful demand to increase productivity of biopesticides for pest management and sustainable agriculture. Recently, phytochemical and natural product studies have led to the discovery of enormous number of compounds with a variety of chemical structures and bioactivities. Botanical pesticides are effective alternative sources and are not harmful and environmentally safe and it is also known as 'phytochemical insecticides' and 'greenchemical insecticides'. In general, botanical insecticide investigators mostly concentrate on searching and screening of plant materials for insect pest management. In addition, newly emerging botanical insecticide scientists do follow the same research trend. Recently, Isman [11] reported that, publications numbers are increasing in botanical insecticide research in several countries especially in India, China and Brazil; but the application value is less. An alternative way of research is required to fulfill the demand of production of botanical pesticides for promoting of organic farming and integrated pest management (IPM) in developing countries. India is the 12th largest producer of chemical pesticides in the world. Figure 2 shows the area treated under the synthetic chemicals and biopesticides in India during the period, 2011-2016 [12]. Of the total pesticides produced, the utilization of synthetic pesticides in India is about 50% on cotton crop alone followed by 17% on rice [13]. Presently, the average per hectare consumption of pesticides in India is about 280 g/ha and consumption of pesticides is increasing at the rate of 2 to 5% per year. It is noteworthy that the consumption of chemical pesticides in India is very low (381 grams per hectare) when compared to the global consumption (500 grams per hectare) at present. Pointed out that more than 40,000 metric tons of pesticides are used in India every year [13].

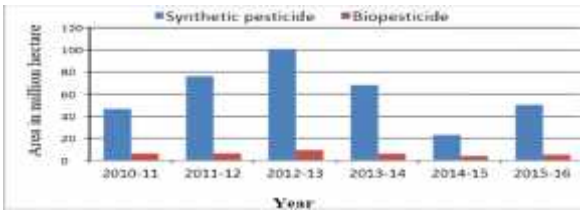

Fig.2- Area under use of chemical & biopesticides during 2010-11 to 2015-16 in India.

Biopesticides Consumption and Distribution Pattern in India: There is a wide regional variation in the use of biopesticides across the states in India. Figure 3 show State-wise consumption of biopesticides in India in 2016-17. Maharashtra, West Bengal, Kerala, Karnataka, Haryana are the states that account for 60 per cent of total biopesticides consumption

in India. Maharashtra is the leading consumer with 1454 M.T.(Tech. Grade), followed by West Bengal (838 M.T. Tech. Grade) and Kerala (622 M.T. Tech. Grade). Rajasthan, Sikkim, Mizoram, Goa, Meghalaya, Nagaland, Manipur and Utter Pradesh are relatively the poor consumers of biopesticides [14]. Rest of the states such as Karnataka, Haryana, Madhya Pradesh, Chattisgarh, Bihar, Tamil Nadu, Gujrat and Odisha can be included in the medium users group of biopesticides consumption [15].

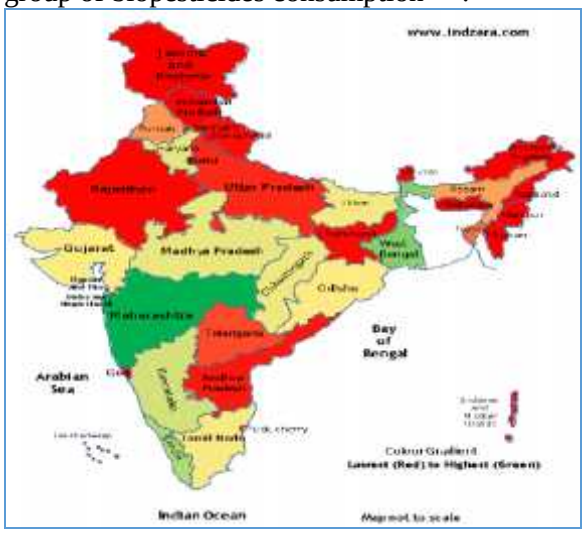

Fig.3- Consumption of biopesticides in India 2016-17

Interventions of Indian Government in promoting Biopesticides: Indian government started initiative for the production and promotion of biopesticides. Department of Biotechnology (DBT) spearheads the promotion of bio pesticides, especially research funding and production. Indian Council of Agricultural Research (ICAR) started 31 bio-control production facilities while DBT supports another 22 bio control laboratory. National Agriculture Technology Project also led Biocontrol labs only in Andhra and TN has more than 200 labs. The Insecticide Act of 1968: simplify registration for speedier development of bio pesticides. The National Farmer Policy 2007 treated on par with chemical pesticide for promotion and utilizations.

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