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GENERAL ATTRIBUTES OF BIOPESTICIDES: A REVIEW

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***Abstract*:** One of the most dreadful components rich active substances which kills pests and insects is known as pesticide. Pesticides are specifically used as a killing substance to eradicate the organisms which poses threat to agricultural crops and other plant species. But on the other hand, they have negative impacts on human health and environment such as loss of soil fertility, water clogging and physiological issues that might cause major physiological problems in human beings also. In order to formulate an alternative to prevent the use of pesticide, biopesticides have been introduced. They are mainly aimed to destruct the insects and pest habitation on food crops thereby limiting the issues that were formerly discussed. Biopesticides have been classified based on microbial, plant and biochemical types. So indeed, every country needs to implement the use of biopesticides as a healthier and greater alternative to achieve a sustainable and eco-friendly global diversity.

Keywords: Pesticides, biopesticides, insects, human health, soil fertility, water clogging.

I. INTRODUCTION

From the times of ancient and traditionally cultured inhabitants of Europe and the surrounding countries, people used sulphur for hunting down the classes of arthropods which were major nuisance to the plant and agricultural crops. Also, they used bitterly salts for controlling enormous growth of weeds. The use of arsenic as an insecticide was urged by a Roman naturalist. As well as the Chinese used smoke that produced malodourous compound which helped in protecting the vineyard and creepers from blight and wilt [31]. During the year of 1970-1980, compounds such as pyrethroids, triadimefon and synthetic fungicides were introduced [7].

Beauveria bassiana, a fungus that is most parasitic to population of the arthropods such as caterpillar, bed bugs and mites etc., The effectiveness is introduced when the spores of the fungus come into contact with the insect, where they germinate, penetrating the cuticle, and grows inside thereby killing it within a short period of time [2]. After the most used biopesticide *Bacillus thuringiensis*, the effective fungal species *B. bassiana* had the potential of destructing pests such as the leaf curling caterpillar [6, 20]. *Haritalodes derogata* (leaf curling caterpillar), which belongs to the lepidoptera family is a pest that is commonly seen in Hibiscus sp. Pupation takes place once after the caterpillar rolls the leaves inside it which leads to the premature falling of leaves. *Haritalodes derogata* is widely distributed across all the regions of South Asia [6, 13, 34].

II. PESTICIDES

Pesticides are chemically synthesized derivatives which are involved in the eradication of pests and insects which affect the wide variety of almost all the plant species. In the action of targeting pests, the actively synthesized pesticides are very much effective to the former. As the pesticides contain chemicals strong enough to repel or destroy the harmful pests, they are toxic to birds, animals, plants and cause serious effects on air, water and soil. The accumulation of various chemicals such as organochlorines in organisms cause endocrine disorders, neurological damages which are having chronic effects.

2.1. EFFECTS OF PESTICIDES

2.1.1. Effects on environment:

The mass killings of non-human biota including insects, birds, amphibians, and small mammals were reported due to the disposal of enormous amount of pesticide in the environment [19]. When pesticides are applied on plants, they will enter the environment through transfer and degradation. The chemicals present in the pesticides will move from target area to other areas by adsorption, leaching and get accumulated in the soil and cause serious toxic effects on microbial flora and fauna. The dosage of chemicals and best period application helped to evaluate the early reports and incidents that were implemented to the regulations for pesticide applications [31].

2.1.2. Effects on agriculture:

Apart from the common benefits for the crops due to the uses of pesticides, rodenticides, herbicides, fungicides etc., these agents provide protection to the cattle from diseases and safeguard the humans from vector borne diseases like malaria. The spray application over the fields has resulted in a worldwide chaotic stress for the natural biota which counts for the quantities of chemicals present in it. Pesticides which remain as residues in water and soil contaminate them thereby entering the food chain which results in the ingestion of these compounds by the human population along with their regular diet [19].

2.1.3. Effects on human health:

In recent years, the Glyphosate based herbicides results in the threat of intervention in the disruption of human cell lines, rat testicular cells and spotting DNA damages also [12]. It also causes acute cell death in human cutaneous cells and testicular issues in model animals also. Also, there are notable evidences which results in the stoppage of cell transport. Statistical analyses of the glyphosate usage in the weed management raised complications in the disorders line such as hypertension, diabetes, Parkinson's, Alzheimer's disease, cancer etc. [18, 30]. In addition to all these things, there are major drawbacks which led to the ability of glyphosate to potentially develop gluten intolerance, a problem associated with the outcome of possibly causing reproductive issues and non- Hodgkin's lymphoma.

2.1.4. Effects on food:

There are things such as livestock, fish and poultry feed that contain enormous number of pesticides during application or manufacturing process that tend to occur in the vicinity or during transportation these are accidently mixed up along with the feed. Also, there are other situations wherein the undesirable residues may remain in the agricultural products due to improper plant uptake, slow degradation, low volatility, or inappropriate application of pesticides. The other sources may include the improperly fumigated cars, trucks, ships, or warehouses used for transport and storage of human food and animal livestock [8].

III. BIOPESTICIDES

A biopesticide is a naturally synthesized agent which is been mainly involved to control the pests and insects in a protected manner [25]. Biopesticides include various types of compounds including microbial populations such as entomopathogenic nematodes, baculoviruses, and the pheromones [28]. Pheromones are the chemical compounds secreted by the insects that plays a major role in the mating, moulting, and feeding behaviour of the insects. Pheromone containing biopesticides are used as mating disruption agents in order to control the insect population and are receiving increased exposure of demand as alternatives to chemically synthesised pesticides and insecticides [23]. During the recent years, the usage of biopesticides have been greatly raised up with the introduction of microbes that was reported in a statistical analysis from the European Union and the United States of America [4].

Among the other identified pathogenic microbes, the invertebrate pathogenic organisms are comparatively employed as active substances in the initiation of pest management and reported to be generally safe and non- toxic to the non-target species in comparison with the chemically synthesized pesticides. This is absolutely in relation to the mode of efficacy limiting to their narrow range of species variation [17, 29]. On the other hand, they develop the potential of hindering their resistance towards the organisms also.

The microbial active agents such as bacteria, fungus, virus and other extra beneficial organisms like protozoans and nematodes have higher capability of providing resistance against the bacterial and fungus diseases such as wilt, blight, and mosaic viral diseases also.

3.1. TYPES OF BIOPESTICIDES

A. Microbial pesticides: Microbial pesticides are the pesticides that contain a microorganism such as bacterium, fungus, virus, algae, etc. as an active ingredient. Microbial pesticides are found to be more effective in controlling various pathogenic pests. Each active ingredient is specific to its target pests. The mode of action of bacteria, fungi, viruses are different for different pests [14, 15]. Cry gene that is isolated from the soil bacterium *Bacillus thuringiensis* is used to produce plants that are resistant to different types of pests such as cotton boll worm which is a pest that affects cotton plant all over the world [3, 11]. Microbial pesticides should be monitored in order to ensure that it will not harm humans as well as other living beings.

B. Biochemical pesticides: Fatty acids, pheromones, plant extracts are used to control pests by interfering the growth and mating. Conventional pesticides that are synthetically produced can kill or inactivate the pest [33]. Biochemical pesticides contain compounds like insect pheromones that interfere mating as well as attract the pests to trap them. Pheromones are used to inspect insect population as well as to control them.

3.2. ACTIVE INGREDIENTS IN BIOPESTICIDES

Active ingredients used in biopesticides are the microbes that are used to control the target pest without causing any problems to the host plant. An active ingredient prevents the harmful effects of a pest on its host by destroying or mitigating the former. Biopesticide containing the active ingredient *Bacillus thuringiensis*, a soil bacterium, is used to control the cotton boll worm that affects the cotton cultivation all over the world. *Bacillus thuringiensis* is considered as the pioneer of active ingredients that are used in biopesticides. Snowdrop lectin, a recombinant protein derived from *Galanthus nivalis*, are known to cause toxic effects on insects [10].

3.2.1

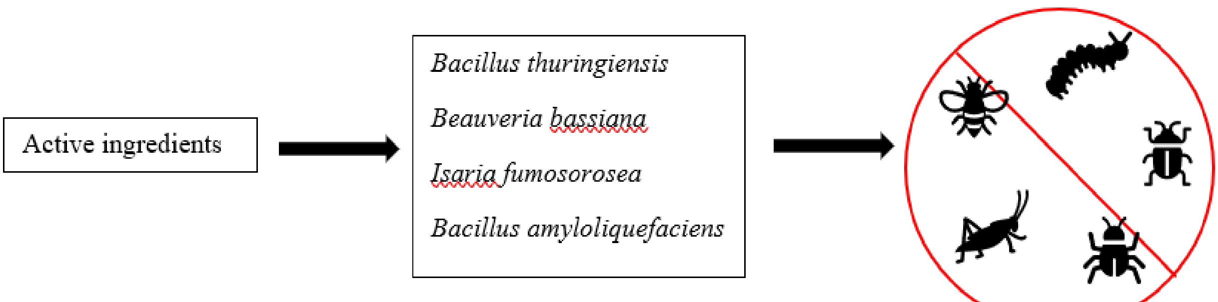

Fig.1. Active ingredients and target pests

Beauveria bassiana: A fungus that infects insect pests directly through contact with the insect cuticle. The spores adhere to the host insect, germinate, and produce enzymes that attack and dissolve the cuticle, allowing it to penetrate and grow within the insect's body. When the growing hyphae reach the nutrient-rich haemolymph, the fungus is capable of budding into single-celled, yeast-like blastospores (or hyphal bodies) that are specialized structures to rapidly proliferate and exploit nutrients, colonize internal tissues, and evade the host immune system [1, 21, 24]. A variety of toxic metabolites (antimicrobial peptides) are produced during colonization [16].

They are involved in host immune suppression, accompanied by destruction of host internal tissues and nutrient depletion, and hence leading to host death [2, 22, 26, 27]. Overall, *Beauveria bassiana* is a zero threat to other organisms and humans that sustain along with the nature [9, 35].

3.2.2. *Bacillus thuringiensis*: Insect pathogens that rely on insecticidal pore forming proteins known as Cry and Cry toxins to kill their insect larval hosts. The mode of action of the three domain Cry toxin family involves sequential interaction of these toxins with several insect midgut proteins facilitating the formation of a pre-pore oligomer structure and subsequent membrane insertion that leads to the killing of midgut insect cells by osmotic shock [3].

3.2.3. *Isaria fumosorosea*: This fungus is highly pathogenic toward a broad range of pests, including whiteflies, aphids, thrips, soil-dwelling insects, and spider mites. Spores applied as a foliar spray or soil drench germinate on contact with the target pest, and the growing fungus then penetrates through the cuticle or natural openings to proliferate inside. The insect or mite stops feeding and dies soon afterward, often with dark spots at infection points as the only visible sign of fungal infection. *Isaria fumosorosea* can infect all life stages of the pest (eggs, nymphs, pupae, and adults) [7, 32].

3.2.4. *Bacillus amyloliquefaciens*: Produces antimicrobial metabolites that directly kill plant pathogens by disrupting their cell membranes. It promotes plant growth by improving nutrient uptake and through hormonal interactions. It triggers the plant's immune responses through induced resistance (IR), and it competitively excludes pathogens via colonization to prevent infection [5].

RECENT ADVANCEMENTS

Biopesticides have been gaining increased attention and interest among those concerned with developing environmentally friendly, safe and Integrated Crop Management (ICM)-compatible approaches and tactics for pest management [4, 32]. Thus, biopesticides are now being recognised as growing components in the crop-protection armoury. Key elements impacting future developments and acceptance include limited funding for research and development, limited shelf-life, high specificity (which can also be an advantage), limited persistence in the environment (in some instances also considered an advantage) and variable field performance [5, 19].

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* [23, 25].

In-depth research on biopesticides is needed in many areas such as production, formulation, delivery, and commercialization of the products. Most of the biopesticides are based on the locally available plants like neem, garlic, triphala, etc. which can be easily processed and made available to the farmers to improve biopesticide consumption. 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 [11]. 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.

CONCLUSION

Biopesticides provide a wide range of options for controlling particular pests or diseases which is of great relevance in the context of increasing resistance to agrochemicals; for example, there are more than 500 insect pest species known to be resistant to one or more insecticide. The extended range of options provided by biopesticides, particularly when used as a component of Integrated Pest Management (IPM) or in conjunction with agrochemicals, can offer an attractive marketing strategy. 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.

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