The Use of Bio-control Agents in Mulberry Pest Management: Successful Techniques and Important Issues

ABSTRACT

Since bio-control agents target specific pests without affecting the usefulness insects or/and damaging the soil and water resources, it plays a role in conservation of ecological balance in the environment. This method does not in any way influence the sustainability of environment through pest control as required by sustainable agriculture. Since bio-control agents are known to be harmless to human beings and other organisms that may be of equal importance in the ecosystem such as pollinators, wildlife etc., they also have safety advantages. This is a big step forward to eradicating pests as compared to the chemical pesticides which have been known to affect the human lives and other wildlife. In the meantime, the bio-control agents may more or less cost effective in the long run. Because bio-control agents could offer continuous control of pests with minimal extra cost, it is possible, even when the outlay of obtaining and developing such organisms is more expensive than straightforward chemical applications. Further, the use of bio-control agents may reduce the reliance on traditional chemical pesticides and hence cost outlay and pest control costs and also reduce the probabilities of pesticide resistance.

KEYWORDS: Bio-control, Bio-control agents, Challenges, Mulberry, Pest management, Strategies

INTRODUCTION

Bio-control of pests and diseases is quite successful in modern agriculture. Recent developments in the fields of scientific pest management technologies have enabled researchers to find alternative solutions to the synthetic limitations in sericulture. Thus, the time is ripe to discuss the innovative growth-promoting and biological control agents, including experiences with commercial products employed for the efficient management of harmful insects in mulberry cultivation [34].A variety of insect and non-insect pests, as well as hosts of parasites (fungi, insect, and mite parasites), occur in silkworm sericulture. Mulberry is the sole host plant for silkworms, and it is grown in over 70 countries across the world. Over 96% of the world's silk is

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produced from mulberry grown in India. The management of pests certainly requires artificial measures, such as the application of pesticides. Mulberry is subjected to numerous pests, including mosquitoes, dipterous larvae, lepidoptera, mealybugs, and silkworms. These insects can have an impact on the quality and quantity of leaf yield crop. The deciduous spray of broad-spectrum pesticides may greatly promote crop production, but pests can become immune after repeated treatments. The sting of sucking pests and broad-spectrum pesticides has many harmful effects on unusual fauna and animals. The alteration and fragmentation of non-target organisms, including pests of crops and soil microorganisms, in response to pesticides. Aviation could also harm humans, as well as undesirable chemicals induced by broad-spectrum pesticides[35].

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Human can decrease the adverse effects of long-term use of broad-spectrum pesticides by developing appropriate non-chemical procedures, mechanical methods, and biological control. A number of researchers have also worked to control pests by utilizing non-chemical techniques around the globe. Biopesticides include neem products (*Azadirachta indica* oil, Azadirachta indica kernel liquid, etc.), tobacco products (*Nicotiana tabacum* extracts, etc.), Mexican marigold (*Tagetes patula* extract), gliricidia (*Giricidia extract*), contact poison (Magnesium fluoride, K2SiF6, etc.), and biological control agents. Bio, botanical, and contact actives are used in the control of pink mealybug. Bio-control agents or biocontrol are mechanisms to avoid large increases in pest populations due to competition or predation[36; 37].

The mulberry or *Morus* sp. is an important agricultural product used in the production of sericulture and is renowned for being used in the making of silk [8]. Leaves are the sole feed of silkworms (*Bombyx mori* L.), which spins a cocoon out of fibers and produces silk, an article of immense cultural and market value on the global level [3]. Apart from their use in silkworm farming, the plant is used in traditional medicine, fruit production and as ornamental trees in landscaping. The demand for mulberries and their products worldwide indicates how important it is to sustain a healthy, high-yielding type [9].

Nevertheless, like all similar crops, mulberry has many threats in the form of pests and diseases that pose danger to the trees' health and productivity. Some of the common pests include Aphids, Scales, Borers while the diseases include fungal, bacterial, viral, etc. These threats can cause significant economic losses and impact the quality of the mulberry leaves used in the sericulture [10]. In response to these challenges, traditional pest management methods have mainly focused

on the use of chemical pesticides. These chemicals although efficient in pest control have the following impacts; pollution of the environment, toxicity to organisms that are not pests and potential harm to man. Additionally, excessive reliance on chemical pesticides can result in pest resistance thus their effectiveness declines over time and require more of it or a stronger chemical [12].

These problems have been met by a shift towards more sustainable organic farming methods that include reduced use of chemicals and enhanced resource conservation. Biological control agents have been found promising when applied as a replacement to synthetic pesticides [24]. These agents, which play a part in managing the biological balance of pests, are either living organisms or substances that are extracted from live organisms. Using bio-control agents in pest management is a significant difference in pest management aiming at reducing the excessive reliance on artificial substances that are not friendly to the ecosystem [14].

Bio-control agents are typically categorized into three main groups: These include predators, parasitoids, and pathogens. In this case, predators are living things that have a direct control on other pests through feeding on them. Parasitoids deposit their eggs usually on or inside the pest insects and the larvae consume and destroy the host [28]. These are organisms that invade and destroy pests, and normally target specific pests or stages of pest's life cycle. The various forms of bio-control agents have different modes of action for an integrated approach to pest control [18].

However, the use of bio-control agents in mulberry has its difficulties involved in the process. Since most bio-control agents are species specific, one cannot completely eliminate pest problems by using these agents alone; a precise choice and application of the bio-control agents are required for optimum pest control [15]. Temperature and humidity also pose a challenge influencing the efficacy of bio-control agents and thus the need to make adjustments. Furthermore, the integration of biocontrol agents to other pest management practices such as cultural and physical control entails proper planning and management [20].

The use of bio-control agents and products in mulberry farming is still growing due to evolving research and technology. The following is likely to improve the effectiveness and flexibility of bio-control agents through genetic improvements and different formulations: More extensive

ecological study of bio-control agents, pests and their environment is therefore required to enhance bio-control efficacy in various conditions.

UNDERSTANDING BIO-CONTROL AGENTS

Bio-control agents refer to those living organisms that are used in the control of pests and diseases through efficient natural processes. They can be broadly categorized into three types: predators, parasitoids and pathogens and include organisms such as insects, spiders, nematodes and fungi.

i. Predators: These are organisms that feed on other pests as opposed to plants, animals and other food materials that are obtainable in the environment. The parasitic insects including lady beetles, the lacewings and spiders serve as biological control agents to suppress pests in mulberry production.Predatory agents are animals that can capture and feed on prey, limiting pest populations.

ii. Parasitoids: Parasites are usually oviposit on or in another insect (host). Its larvae which are in the process of developing feed on the host and finally kills it. Some of the commonly employed parasitoids include the wasps that are selective in the pests they attack in mulberry plant.

iii. Pathogens: These are independant causal organisms and include bacteria, fungi, viruses and nematodes that infect and kill pests. Some bioagents in the form of pathogens have been found to provide significant level of suppression of certain pests and diseases in mulberry [32].Therefore, pathogens are utilized to reduce hemolymph cellularity and in some cases to induce apoptosis in insect hemocytes. Pathogens are also developed in the fat bodies. The released spores hence multiply in numbers to suppress hemocytes, facilitating various beneficial reactions. However, ingestion of toxins (spores) is essential. Once the enterotoxic spores exert their action, infection in the hemocytes takes over to complete the season of suppression. Pathogens due to these versatile activities are considered as successful bio-control agents possessing the potential to manage crop pests sustainably. Moreover, pathogens are not specific in infecting only a few CNA, unlike parasites that have to be hosted by one or two CNA and, therefore, have suggesting better applicability in pest managing tropical crop ecosystem. For addressing the issue of critical concern, we have to

look at more information including the exclusion of other infection routes and immune protective strategies if developed [38].

KEY BIO-CONTROL AGENTS USED IN MULBERRY PLANTATION

Predators

i. Lady Beetles (Coccinellidae): They are most suitable for agrophotous arthropods such as aphids, scale insects and other pests of soft-bodied nature. This is a plus since they feed aggressively and ensure that pest infestations are minimal at all times.

ii. Lacewings (Chrysopidae): Lacewing larvae that are often referred to as 'aphid lions', because they feed on aphids, whiteflies and other similar insects. They are very beneficial in that they can greatly minimize pest populations in mulberry orchards.

iii. Spiders: Orb-web and jumping-spiders are only some of the favoured spider species that feed on different pests. These are also useful in the general pest management involved in mulberry farming [22].

Parasitoids

i. Trichogramma Wasps: These are small parasitic wasps that lay their eggs into those of other moths and butterflies possibly including the mulberry. Trichogramma sp. is first of all parasitic at the egg stage of pests. it plays a role of pest control in early stages to avoid occurrence of a big crisis.

ii. Braconid Wasps: These parasitoids are known to parasite the caterpillars and other larval stages of the pests. They are useful at controlling pests including the mulberry borers [26].

Pathogens

i. *Bacillus thuringiensis* (Bt): These toxins are aimed at caterpillars and other insect larvae that are invulnerable to other kinds of bacteria. Formulations of Bt are typically employed in their organic mulberry plantation for the management of pests such as borers [11].

ii. *Beauveria bassiana*: This fungus parasitize and causes death to a number of insect pests. At present it is applied to control pests including whitefly and spider mites in mulberry [22].

iii. *Metarhizium anisopliae*: The other useful fungus is M. anisopliae that can be useful in controlling pests that dwell on the soil and feed on mulberry plants; this control is particularly helpful in controlling beetles and other ground feeding insects [64].

EFFECTIVE STRATEGIES FOR IMPLEMENTING BIO-CONTROL AGENTS

The application of the bio-control agents applies an overall method of pest control where bio-control agents are used as one of the segments. Several key strategies are essential for effective use:Several key strategies are essential for effective use:

Choice of Effective Bio-Control Agents: The effectiveness of a number of these bio-control agents depends on the choice of correct agents for specific pests and conditions of the environment. It is made depending on the type of the target pest, effectiveness of the agent used and the other conditions prevailing from time to time. Such parasitoids as Trichogramma sp. To control the moth and butterfly, the wasps preferably seek the egg stage of the insects; lady beetles (Coccinellidae), predators work effectively on aphids and scale insects. Entomopathogenic fungi such as Beauveria bassiana intends to kill a broad spectrum of insect pest whereas Bacterial pathogens as formerly mentioned, for example Bacillus thuringiensis (Bt) is applied against caterpillar pests. To carry out this selection it is crucial to note the correct identification of pests and also to understand the life cycle and behaviour of the bio-control agent [13].

Timing and Application: More generally, the action time and the way of application of the bio-control agents must be considered. The use of bio-control agents in a way that optimize the timing of a pest population, is scientifically known as sensitive timing [4]. Suppose, to guarantee that the parasitoids are able to parasitize the eggs before they hatch, for example, introduce Trichogramma sp. wasps at the time of the moths when the female is laying eggs. The movement of the bio-control agents throughout the crop should have been ensured by the application techniques employed [27]. To completely cover contaminated areas this may need to involve using agents with specific methods of coverage, or to let the agents seep out bit by bit in specific time frames.

Monitoring and Evaluation: Evaluations are needed at a more frequent basis to identify the extent of the effectiveness of bio-control agents. The bio-control agents inhabiting the area and

the sporadic surveys of pest populations help in ascertaining whether the bio control agents are having an effectiveness. Monitoring also shows that it is possible to adjust the extent of the effort tactically whether by increasing the frequency of the releases or changing the application techniques due to the initial efforts being insufficient. The decisions are based on information drawn from monitoring endeavours ; these also help in the progressive enhancement of bio-control strategies [5].

Benefits of Using Bio-control Agents

Use of successful bio-control technological intervention in mulberry agro-ecosystem offers distinct advantages compared to the conventional chemical interventions. Biopesticides containing living microorganisms such as bacteria, fungi, viruses, protozoa, and beneficial nematodes are potential biological control agents to suppress a wide variety of pests and plant pathogens using multiple modes of action. The use of these kinds of bio-control offers great potential to control the various pests at mulberry and have several advantages. The major advantage is that they leave very few or no residues in both the host plants and environment. The microorganisms are destroyed rapidly by environmental factors. The requirement of beneficial microorganisms for bio-control agents for such requirements is lower. These agents offer attractive environment restoration. As the incidence of pests and pathogens is considerably reduced, there is no longer a need to use large quantities of chemicals. Consequently, toxic chemicals do not spread throughout the environment. Bio-control agents offer long-term pest suppression in comparison to chemical control methods, whose impacts tend to weaken after several generations of treatment. The continuous use of chemicals may result in pest resistance to the pesticides used. Spraying synthetic pesticides leads to the formation of pesticide residues on mulberry foliage, which affects food products and environmental health. In the medium and long-term, the use of conventional pesticides results in inflation and reduced efficiency. Bio-control agents or bio-pesticides offer a cheaper alternative to pesticides. Using natural predators to minimize pests and harmful insects avoids the direct costs associated with pesticides and their application. In fact, the reduction in the use of chemicals helps to minimize the risk of pest resurgence.

The following are benefits of using bio-control agents:

i. **Environmental Benefits:**Bio-control agents are better than chemical pesticides from the point of view of environmental conservation. They decline on the use of synthetic chemicals, the possibility of pesticide residue in food, water pollution and soil pollution is also eliminated [17].

ii. Sustainability: Bio-control agencies have been found to help in the sustainable production of mulberry since they foster the natural pest control. They have minimal effects on the environment retaining bio-diversity and are far less probable to cause pest resistance as is the case with chemical pesticides [23].

iii. Safety: Compared to chemical pest killers, this is one way of pest control that has little impacts on health hazards. They are normally biodegradable, as well as having low toxicity to humans and other species of beneficial insects and wildlife [19].

iv. Cost-Effectiveness: When it has been set up, bio-control agents for pest management are long-term. Because they may have setup costs in their introduction and the costs involved in pest management if reduced through the use of these organisms may prove cheaper in the long run mainly because of little or no use of chemicals [33].

CONCLUSION

In conclusion, bio-control agents are an important significant step in the sustainable control of diseases and pests in mulberry production system. Their respective roles in the current agriculture are well demonstrated by the level of efficiency they have in providing pest control but at the same time minimizing on the rate of harm that they cause on the environment, the level of economic benefits that they bring in addition to the health and safety of the people who are involved in the farming process. The use of bio-control agents in the integrated pest management system will indeed become paramount with improvements in science and technology so as to retain the health of the mulberry crops as well as the yield. As the present problems addressed in the production of mulberry and with the advancement of the upcoming technologies attach the solution to it, the agricultural method assuring more stability and sustainability to this important crop will not only build the future but retains the prosperity and viability it needs. In the farming of mulberry, bio control agents are one the most important components of integrated pest management and have proved be an effective substitute to chemical control. As the global demand for mulberry products especially in sericulture production improves it is strategic that

there be strong and improved yielding crops. Introducing parasitoids, diseases and predators is consistent with methods of modern agriculture that first of all preserves crop health, has a positive balance of cost and income, and does not have a detrimental effect on the environment.

Future Prospects and Research Directions

In the future, we believe that molecular and genetic advancements and new technologies with user-friendly approaches should be developed for isolating, producing, and enhancing the efficacy of these bio-priming agents and biopesticides. In addition, the use of other sources for obtaining or isolating novel microbial isolates or their metabolites for the control of multiple pests attacking the mulberry fields has potential and is an area that needs to be explored. Considering the advantages and future growth, integrated use of bio-priming agents or bio-inputs could be a trend that would be widely accepted in the management of insect pests attacking crops and would be a promising innovation in total.More biochemical and molecular research is needed to be conducted to reveal important genetic or transcription regulation, payment pathways stimulated by these BCA compounds that are related to defense systems. Research needs to be initiated on various aspects, including: (1) BCA sprayed mulberry leaves expecting that applied at one concentration (100 mg/mL^{-1}) to determine dose minimal important application (2-10 mg/mL^{-1}), even from Bt formulations derived from different *Aspergillus* isolates their treatments against different *A. flavus* strains. Therefore, a kind of performance evaluation, or additional comparison research, or an examination of the potential BCA versus others, is not restricted to *A. flavus* or mulberry fruits.

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