



Review

Biopesticides: An overview on their mode of action, utility and importance

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Abstract: Agriculture has an imperative role in the economy of developing countries. It is associated with a variety of food materials such as vegetables, fruits and cereal crops. Many people depend upon it as a staple meal and as a source of their income. These agricultural food products are broadly damaged by a variety of pests including insects, mites and rodents. The consequences of damage are manifested in both quantitative and qualitative forms. Over the years, synthetic pesticides have been widely used for pest management, but these pesticides pose hazards to the environment and human health, and long-term repetition of these products develops resistance in insects, due to which their efficacy starts to reduce, or they have no effects on the insects after a certain period of time. Therefore, the production and exploration of maximum degraded natural resources are very important to prevent these serious threats. Biopesticides are usually derived from several plant species which are easily available and cause less or no adverse effect on the environment. Biopesticides are generally host-specific, therefore it does not affect the non-target

organisms including humans. Small quantities of bioproducts prove to be effective and useful against pests and are also easy to decompose. Biopesticides can be used as safer alternatives to controlling pests and are frequently part of Integrated Pest Management plans.

Keywords: Biopesticides, Agriculture, Environment, IPM.

Introduction:

Agriculture has constantly been affected by the biocidal activities of various pests which have led to rapid crop loss. More than 30 per cent shortage in crop production has been reported worldwide due to pests (Oerke et al., 1994). Pesticides are the type of pest management agents or tools that help in the management of injurious pests found in the environment. Management does not suggest the extirpation of pests, it simply promotes the finding of an alternative that is less toxic and more effective as well as reduces environmental damage. Pesticides often contain chemical compounds or inorganic substances. Whereas such products which are typically made up of natural resources such as plants

and their derivatives are mentioned as biopesticides. Biopesticides and their by-products are basically applied for the management of pests that are harmful to crops and other food products (Mazid et al., 2011). The efficacy of bio-products can be comparable to synthetic insecticides. Some pesticides incorporate more toxic chemical components that are not easily degraded and take plenty of time to break down and the presence of these chemicals in the environment makes the soil and air to be polluted. The substantial use of pesticides can damage the community of soil-dwelling microorganisms as well as it also reduces the biodiversity in the soil. Moreover, these compounds interrupt the biochemical processes of nutrient cycling resulting in soil erosion and soil contamination. The biggest deficiency of synthetic pesticides is the lack of host specificity, which eliminates further beneficial insects or pollinators during the spraying process (Tosi et al., 2018). Pollinators such as bees and butterflies are major aspects of the ecosystem and their destruction is hazardous for the environment as well as human beings also (Aslan et al., 2016). Prolonged exposure to pesticidal particles can lead to serious health disorders in humans. The impact of pesticide exposure can be categorized from moderate allergic reactions to major disorders such as genetic mutations that can lead to cancer. On the basis of entire threats, there is a huge demand for secure and effective pesticides that are host specific and also environment friendly. For this reason, bioproducts have fascinated people towards them in the last few decades (Copping and Menn, 2000). When biopesticides are used for pest management, their efficacy can be similar to synthetic pesticides. Botanical pesticides do not sustain issues that are encountered

by using synthetic pesticides. These are toxic to target pests while mild to beneficial insects. The utilization of biopesticides is convenient; it does not require any specific precautions or experts to apply them against insects, so anyone can use them without any kind of risk. Apart from this, their degradation is acute and suitable, so there is no residual problem initiated in the food products and environment after using them. This paper summarizes the overall significance of biopesticides in addition to discussing their contribution to a safe and chemical-free environment.

Scopes of Biopesticides

Over the past few years, attempts have been assembled to minimize the environmental threats induced by synthetic pesticides. Bioproducts have made a decisive contribution to these efforts. These are not just a significant alternative to synthetic pesticides but additionally provide a crucial subject to the researchers to study over it. Biopesticides and their by-products bring down the environmental concern along with providing residue-free healthy food to the consumers. Therefore, the popularity and commercial value of biopesticides is enlarging gradually, as it does not render insects resistant over the time, and its effectiveness never diminishes.

Mode of Action

Mode of action refers to the technique of pesticides applied against the target pest. Some of the pesticides employ more than one repulsive mechanism to repel the pests so it is helpful to understand their different working criteria. Moreover, it can also prevent insects from developing pesticide resistance. Biopesticides usually adopted non-toxic strategies towards the target pests (Dar and Padder, 2016). They are capable

of managing insects in a diverse manner. For example - Deterring feeding, repelling their life stages as well as sterilizing adults

etc. All of these mechanisms are associated with the mode of action.

Table 1: List of certain plant species that are globally utilized as biopesticides.

Common name	Scientific name	Family	Active ingredient	Target pests
Neem	<i>Azadirachta indica</i>	Meliaceae	Azadirachtin, meliacin, gedunin	aphids, scale, beetles, whitefly, leafhoppers, weevils
Basil	<i>Ocimum basilicum</i>	Lamiaceae	eugenol, linalool, methyl cinnamate	Bugs, Caterpillars, Fleas
Lemon	<i>Citrus limon</i>	Rutaceae	Limonene, Linalool	Flies, weevils, Mites, House crickets
Pyrethrum	<i>Chrysanthemum coccineum</i>	Asteraceae	pyrethrins	Ants, Roaches, Flies and Ticks
Lemongrass	<i>Cymbopogon citratus</i>	Poaceae	Citral, citronellol, myrcene	Bugs, Mosquitoes, Aphids

Neem based products :

Neem (*Azadirachta indica*) occupies a fundamental position among botanical pesticides. It has been globally known as a medicinal plant. Along with medicinal properties, its pesticidal and feeding inhibitory characteristics makes it distinctive among other plant species (Mordue 2000 and Morgan, 2009). Apart from the leaves and bark of this plant, their seeds, flowers and fruits also contain effective pesticidal properties. Different parts of this plant incorporate numerous active ingredients including azadirachtin, meliacin, gedunin, salanin, and nimbin etc. among which azadirachtin is a major component of neem. Occupancy of these ingredients in a neem plant makes it toxic or poisonous towards the harmful insect pests of the environment. The components of neem act in different manners against insects similarly azadirachtin has its

unique strategy to repel the pests. It does not terminate the pests immediately, rather it inhibits their activity of growth and reproduction (Pavela and Holy, 2004). The metamorphosis (egg to adult) in insects occurs with the help of various hormones secreted by the indications of the brain. Neem based products interrupt the portions of their brain that induce these essential hormones to be secreted. Consequently, insects are unable to moult and their life cycle remains incomplete. Furthermore, they negatively affect the fertility of insects, resulting in a drastic decline in their population (Biswas et al. 2002; Garcia et al. 2006).

Basil based products :

Basil (*Ocimum basilicum*) is an eminent herb belonging to the family Lamiaceae. It is prominently known as 'Tulsi' in India. Basil possesses a huge number of

analeptic properties which makes it influential in the field of Ayurveda. Several species of Basil plants comprises numerous active ingredients namely linalool, methyl cinnamate and eugenol etc. which proves to be helpful in repelling harmful insects (Awasthi et al., 2007). Sometimes the pungent odour of basil is sufficient to drive away leaf sucking insects like leafhoppers, grasshoppers, aphids and caterpillars. Eugenol is the major component of basil that usually acts as insect growth inhibitor (IGI). It also prevents the adult from emerging by suppressing the moulting of insects from larva to adult (Naik et al., 2015; Garg and Garg, 2019).

Lemon based products :

Lemon is a citrus fruit of the Rutaceae family. It is primarily known for its sour taste. Citrus is a good source of vitamin C that provides numerous health benefits for humans. It is an edible product but its leaves, seeds and peel accommodated medicinal benefits as well as insect repellent properties (Dev and Nidhi, 2016). Limonene is an effective component that is significantly associated with citrus and its derivatives. Limonene based products demonstrate the potentiality of eco-friendly pesticides in contrast with synthetic substances and their activity could be efficacious against cockroaches, flies, weevils and beetles (Karr and Coats, 1988; Abdallah et al., 2017). Limonene and its byproducts rupture the wax coating of the insect's respiratory tract, which causes suffocation and leads to death. Furthermore, limonene is an aromatic agent of citrus so its peel extract poses the capacity to get rid of household ants and mosquitoes.

Pyrethrum based products :

Chrysanthemum coccineum is widely known as pyrethrum. The word 'Pyrethrum' not only refers to a generic name of a plant but is also recognized as an organic insecticide itself. Frequent

species of chrysanthemum flowers comprise a combination of chemical compounds that are specified as pyrethrum or pyrethrin. Pyrethrin is an effective component consisting of six compounds that pose insecticidal activity against a variety of pests. Pyrethrins are a type of neurotoxins which means they immediately cause demolition on the nervous system of insects (Dorman and Beasley, 1991). Once the nervous system gets destroyed the insects may not be able to recover and leads to paralysis or death. Pyrethrin based insecticides are less likely to affect warm-blooded animals along with humans so they can be easily utilized against garden flies and household insects.

Lemongrass based products :

Lemongrass is considered to be a herbal, medicinal as well as insecticidal plant. The generic name 'Lemongrass' occurs due to its lemon-like odour and herbaceous morphology. Lemongrass is mostly preferred to be used as a beverage. Due to the existence of major components including myrcene, limonene, citral, geraniol and citronellol, it is labelled as an insecticidal plant. Certain components of lemongrass are regarded as aromatic agents that deterrence vector insects away and facilitate to prevent the vector-borne diseases such as malaria, filariasis, yellow fever and chikungunya (Srivastava et al., 2013; Olorunnisola et al., 2013). Among all these components, citral and citronellol based essential oil hold the capacity to repel insects by non-toxic mechanisms. Both compounds target the sensory nervous system in insect antennae that adversely affect the physiology of insects (Kaur et al., 2019; Mukarram et al., 2021).
Importance and Utility of Biopesticides:

Biopesticides enclose multiple advantages over synthetic pesticides, some of which are as follows -

Biopesticides target only the host pest instead of disturbing non-target organisms. The degradation of biopesticides occurs

conveniently and rapidly which does not cause residue problems on food products.

The active ingredients of bio-products pose numerous modes of action towards the target pest, due to which insects may not be able to develop resistance against them.

Biopesticides are inexpensive and easily available as compared to chemical pesticides.

Biopesticides are less toxic and have friendly behaviour towards the environment.

Biopesticides are used as the main constituent of Integrated Pest Management (IPM) programs and they promote the higher-yielding of crops.

Conclusion:

Contamination of air, water and soil is the main concern of the environment today. Synthetic products are not only harming the environment but further posing a risk to humans and other beneficial insects. They are also responsible for reducing biodiversity. To prevent these negative consequences, it is necessary to find safer alternatives as soon as possible. In the last few decades, bio products have attracted the attention of people towards them. Organic products meet the requirements of environmental protection. They are able to minimize all the threats posed by chemical products. Therefore, the stimulation of bio products by reducing the use of chemicals can prove to be a fundamental step for protecting the environment.

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