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Review Research Paper

Plant Based Biopesticides against Diamondback Moth (DBM), *Plutella Xylostella* (L.) Infesting Cole Crops (Cauliflower and Cabbage): A Review

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ABSTRACT

The diamondback moth (DBM), *Plutella xylostella* is one of the most destructive pests of cruciferous vegetables worldwide, including in India, where it poses a serious threat to Cole crop production. Its rapid development of resistance to conventional chemical insecticides has necessitated the exploration of alternative, environmentally sustainable pest management strategies. This review focuses on the efficacy, modes of action, and potential applications of plant-derived biopesticides for the control of diamondback moth populations. Biopesticides formulated from neem (*Azadirachta indica*), garlic (*Allium sativum*), and black pepper (*Piper nigrum*) have demonstrated significant insecticidal activity, attributed to their bioactive compounds and essential oils. The present study was undertaken to assess the ecology and integrated management of *P. xylostella*, with the aim of identifying the most effective and sustainable approaches to reduce infestation levels, improve crop yield and productivity, and minimize environmental impact.

1. Introduction

The varied agro-climatic conditions prevailing in India are able to produce variety of vegetables throughout the year. Cole crops are the one of largest groups of temperate vegetables, important crops like cauliflower, *Brassica oleracea* var. *botrytis* and Cabbage, *Brassica oleracea* var. *capitata* (Linn.). Cole crops are rich in vitamin A and C. They also contain appreciable amount of minerals like phosphorus, potash, calcium, sodium and iron. Cauliflower is highly vulnerable to insect-pests that causes about 20 to 30% yield loss. The edible part of cauliflower, its inflorescence is known as curd, which consists of a shoot system with short internodes, branches, apices and bracts. It contains 2.4 percent protein and 4.9 percent carbohydrates (Bose and Som, 1986). Cauliflower is highly vulnerable to insect-pests that causes about 20 to 30% yield loss (Estruch *et al.*, 1997). Nyambo and Pekke (1995) reported the insect pests and diseases which attack on cauliflower are army worm, aphids, cabbage worms, flea beetles and club root and black rot.

Cabbage, *Brassica oleracea* var. *capitata* (Linn.), is also known to be infested by several insect pests viz., tobacco caterpillar, (*Spodoptera litura* Fab.), cabbage butterfly (*Pieris brassicae*), diamond back moth (*Plutella xylostella* Linnaeus) and cabbage aphid (*Brevicoryne brassicae* L.) (Mahla RS *et al.*, 2005 and Rao SRK, Lal OP 2005). Biopesticides are a type of pesticide derived from natural materials as animals, plants, bacteria, and certain minerals (Nelson and William, 2004). Biopesticides are naturally derived substances or microbes used to manage pests including insects, weeds and diseases. They are effective for controlling pests and diseases as well as suppress the resistance and resurgence. Integrating plant-based biopesticides into Integrated Pest Management (IPM) strategies can enhance their effectiveness while promoting ecological balance. Research indicates that these biopesticides can complement other pest management practices, such as biological control and crop rotation, resulting in a holistic approach to pest management (Eilenberg *et al.*, 2021).

Diamondback moth (DBM), *Plutella xylostella* (Linn.) (Lepidoptera: Plutellidae) is the serious, cosmopolitan pest of cauliflower known causes about 90% damage globally (Verkerk and Wright, 1996; Sarfraz *et al.*, 2006; Karlsson *et al.*, 2013). This pest being the main cause of low production (Talekar and Shelton, 1993; Sarfraz *et al.*, 2006) is distributed

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throughout the world especially in those places where crucifers are cultivated (Shelton, 2001). Integrated Pest Management (IPM), which focuses on sustainable production, has shown promising results (Asmita paudel *et al.*, 2022). This review paper highlights the integrated eco-friendly management strategies for DBM infesting Cole crops like cauliflower and cabbage. Sagar is one of the key Cole crops producing districts in the state of Madhya Pradesh, India.

1.1 Biopesticides

It can be broadly defined and include all or some of the following: living organisms (insect predators, parasitoids, nematodes and microorganisms) and the products they produce (secondary metabolites produced by microorganisms), viruses, genes (transgenics), insect pheromones and mating disrupters, and plant extracts/botanicals (Chandler *et al.* 2008; Copping and Menn 2000). Biopesticides in India, Biopesticides represent only 2.89% (as on 2005) of the overall pesticide market in India and is expected to increase drastically in coming years. In India, so far only 12 types of biopesticides have been registered under the Insecticide Act, 1968.

2. Life cycle of Diamondback moth (DBM)

The entire life cycle from egg to adult can range from 3 to 5 weeks. Factors such as temperature, humidity, and availability of host plants significantly influence the development rate. In optimal conditions, multiple generations can occur within a single growing season, leading to serious pest problems in Cole crops. Saravaiya and Patel (2005) reported that the first time DBM was originated from North America in 1854. The diamondback moth exhibits a holometabolous life cycle—completing metamorphosis through four distinct stages: egg, larva, pupa, and adult. The duration of each stage is strongly temperature-dependent (Hermansson 2016). Adults of the diamondback moth (*Plutella xylostella*) are small (about 6 mm long), slender, and grayish-brown with distinctive, pronounced antennae. Males typically live for approximately 12 days, while females survive closer to 16 days. Females begin laying eggs very shortly after emergence and continue to oviposit for around ten days (Philip *et al.* 2014; Hermansson 2016). Vadodria (1993) studied the female lay oval shaped eggs, which are yellowish white in color, and becomes dark just before hatching. Atwal (1986) stated that the yellowish eggs of pin head size were laid singly or in batches of 2 to 40 on the under surface of the leaves of cabbage. The larvae emerged from the eggs passes through four instars and larval period ranged between 8 to 16 days but the duration may vary according weather conditions at different locations as reported by Ho Thian Hua (1965), Patel (1968), Butani and Jotwani, (1985) and Usha Chauhan *et al.*, (1997). It was reported that total life cycle of DBM varied from 24 to 35 days on cabbage and cauliflower (Abraham and Padmanaban, 1968).

2.1 Damage Symptom of diamondback moth, *Plutella xylostella*

Significant damage caused by *Plutella xylostella* occurs due to larval tunneling into the heads of crops such as cauliflower and cabbage. Crop damage is often first observed on plants growing along ridges within cruciferous fields. A high population density of *P. xylostella* can result in more than 90% yield loss, and even a few fourth-instar larvae feeding on a cabbage head can render it unmarketable.

2.2 Plant Based biopesticides against Diamondback Moth (DBM)

The Diamondback Moth (*Plutella xylostella*) is a significant pest of cruciferous crops worldwide. Chemical pesticides have been widely used, but concerns over resistance and environmental impact have spurred interest in biopesticides, particularly those derived from plants. The present research work includes the effects of an herbal formulation that are blended of extracts obtained from Neem (*Azadirachta indica*), Garlic cloves (*Allium sativum* L.) and Black pepper (*Piper nigrum*). All the test plant materials are collected from locally available. Aqueous extracts mixtures are prepared, method as adopted by Zaman *et al.*, 2012.

3. Mechanisms of Action

Plant-based biopesticides often contain secondary metabolites that can act as insecticides, repellents, or growth regulators. Common compounds include alkaloids, terpenoids, flavonoids, and essential oils.

3.1 Efficacy of specific Plant-Based Biopesticides

1. *Neem (Azadirachta indica)*: Neem widely studied for its active ingredient, azadirachtin, which has shown effectiveness in reducing DBM larvae and disrupting their life cycle (Jalali & Singh, 2008). Errol Hassan *et al.* (2018) studied the effect of different Azadirachtin concentrations on larval/pupal weight, oviposition, hatching and antifeedant effect on *Plutella xylostella*. Azadirachtin has been shown to induce delayed toxicity, targeting not only the larval stage but also disrupting egg-laying activities in adult DBM populations (Kumar A., 2022). Azadirachtin encapsulated in polymer nanocapsules has been shown to significantly improve the persistence and effectiveness of neem oil against DBM, even under adverse environmental conditions (Sharma V, 2022). Iqbal N. (2022) found that the azadirachtin works best when integrated with other control methods. For instance, combining neem with microbial pesticides like *Bacillus thuringiensis* (Bt) significantly enhanced the mortality of DBM larvae compared to neem alone, highlighting the synergistic effects between botanical and microbial control agents.
2. *Garlic clove (Allium sativum)*: Research shows that garlic extracts can significantly deter DBM feeding and may also have insecticidal effects due to sulfur compounds. The strong odor of garlic disrupts the moths' ability to locate host plants (Saxena & Kaur, 2014). Research found that applying garlic extract resulted in a notable decrease in larval populations against DBM (Yadav & Singh, 2019). Khan, M. I., Hameed, A., & Bafakeeh, O. T (2017) reported

the application of garlic shown to reduce the oviposition rates of female DBM. A.K. Tripathi *et al.* (2009) studied the Garlic extract is expected to reduce pests like aphids and diamondback moths. Garlic extract should be a viable alternative to synthetic pesticides with minimal environmental impact, less leaf damage and higher yields in treated plants compared to untreated plants.

3. *Black pepper (Piper nigrum)*: Isman (2006) studied that the Piperine and other secondary metabolites in black pepper disrupt the lifecycle of DBM larvae, leading to reduced feeding and slower growth. Mahmood *et al.* (2011) investigates the use of black pepper (*Pipernigrum*) as a biopesticide for controlling the diamondback moth population. The black pepper extract is expected to reduce the DBM population due to its bioactive compound, piperine, which acts as an insect repellent and disrupts the nervous system of the larvae (Raja N, 2016). Kwon park (2012) investigated the larvicidal activities of Piper nigrum fruit methanol extracts and its constituents against larvae of the diamondback moth, *Plutellaxylostella*, were investigated using the leaf dipping method. Administering the *P. nigrum* methanol extract resulted in 100 and 97% mortality against diamondback moth larvae at 5.0 and 2.5 mg/mL concentrations, respectively.

4. Conclusion

The study concluded that, the Plant-based biopesticides offer an effective and sustainable option for pest management in Cole crops. By utilizing natural plant compounds, they contribute to the reduction of chemical pesticide, promoting healthier ecosystems and food systems. This approach not only aims to minimize chemical inputs but also supports biodiversity and soil health.

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