



Efficacy of Plant-Based Biopesticides against Diamondback Moth (DBM), *Plutella xylostella* (L.) Infesting Cabbage in Sagar District of Madhya Pradesh, India.

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Abstract

The diamondback moth (DBM), *Plutella xylostella* (L.) is one of the major destructive pest of cruciferous crops worldwide, including in India, where it poses a serious threat to cabbage crop production, causing severe yield losses and developing resistance to synthetic insecticides. The present study evaluated the efficacy of selected botanical extracts as eco-friendly alternatives for its management. Aqueous extracts of neem (*Azadirachta indica*), garlic (*Allium sativum*), black pepper (*Piper nigrum*), and their combinations were tested under laboratory conditions. Laboratory bioassays assessed larval mortality, feeding deterrence, repellency, and developmental parameters. Results revealed that combined treatments, particularly neem + garlic, were significantly more effective than individual extracts. These treatments showed higher larval mortality, strong antifeedant and repellent effects, and prolonged developmental periods of the pest.

The study demonstrates that plant-based biopesticides, especially in combination, often an effective, sustainable and environmentally safe approach for managing *P. xylostella*. Their integration into pest management programs can reduce dependence on chemical pesticides and support eco-friendly agriculture.

Keywords: Cruciferous crops, Diamondback moth (DBM), *Plutella xylostella*, Biopesticides, Pest

Introduction

Cruciferous vegetable such as cabbage (*Brassica oleracea* var. *capitata* Linn.) is widely cultivated across the world due to its high nutritional and economic value. This crop is rich in essential vitamins, minerals, dietary fiber and contributing to human nutrition and agricultural income. However, its production is severely constrained by insect pest such as tobacco caterpillar (*Spodoptera litura*), cabbage butterfly (*Pieris brassicae*), cabbage aphid (*Brevicoryne brassicae* L.) and Diamondback moth (*Plutella xylostella*) (Mahla RS *et al.*, 2005 and Rao SRK, Lal OP 2005). Among the insect pests, Diamondback moth (DBM), *Plutella xylostella* (Linn.) is the serious, cosmopolitan pest that infests cabbage crop at all growth stages known causes about 90% damage globally, severe yield losses and deterioration in market quality (Verkerk and Wright, 1996; Sarfraz *et al.*, 2006). This pest is characterized by a short life cycle, high reproductive potential and remarkable adaptability, making it difficult to manage effectively (Talekar and Shelton, 1993). Management of *Plutella xylostella* has become increasingly challenging due to its rapid development of resistance to a wide range of synthetic insecticides. The indiscriminate and excessive use of chemical pesticides has resulted in:

- ❏ Development of insecticide resistance
- ❏ Environment contamination and ecological imbalance
- ❏ Accumulation of toxic residues in food products
- ❏ Adverse effects on non-target organism including natural enemies
- ❏ Increase health risk to farmers and consumers

Studies have reported that DBM has developed resistance to all major classes of insecticides making chemical control less effective and unsustainable (Furlong *et al.*, 2013). This necessitates the development of alternative, eco-friendly management strategies. Asmita Paudel *et al.* (2022) caterpillar is the most devastating stage of DBM, *Plutella xylostella* that matures and

causes “windowing” damage, leaving only the epidermis. Shazia O.W.M. Reuben (2005) reported the water extracts of garlic stems, fruits of hot pepper and cloves and barks of cinnamon as insecticidal pesticides. Carried out to assess the effectiveness of commonly used spices in controlling diamondback moth (DBM).

Botanical pesticides derived from plants have emerged as promising alternatives to synthetic chemicals. Plants such as neem (*Azadirachta indica*), garlic (*Allium sativum*) and black pepper (*Piper nigrum*) contain bioactive compounds like azadirachtin, allicin and piperine which exhibit insecticidal, antifeedant, repellent and growth-regulating properties.

Neem-based products, in particular have been interferes with insect growth, feeding and reproduction, thereby disrupting the life cycle of pests (Mordue and Nisbet, 2000). Botanical insecticides are biodegradable, environmentally safe and compatible with Integrated Pest Management (IPM) programs (Isman, 2006).

Materials and Methods

Experimental site: The experiment was conducted during January- April 2024 at the research laboratory of Department of Zoology Govt. (Autonomous) Girls P.G. College of Excellence, Sagar (M.P.), India.

Test crop: Cabbage (*Brassica oleracea* var. *capitata* Linn.) was used as the test crop. Healthy seedlings were transplanted in well plots following recommended agronomics (Chatterjee, 2012).

Rearing of test insect: *Plutella xylostella* larvae were reared by following the method of Mondedji D. *et al.* (2015). Larvae were reared in Six to eight week-old cabbage plants and placed in transparent plastic buckets (24 cm height × 20 cm diameter). The buckets were covered with untreated fine net secured with elastic bands to allow ventilation and prevent escape of insects. After adult larvae were transferred to fresh buckets containing cauliflower plants. A cotton

wick soaked in 10% honey solution was provided as supplementary food for adult moths.

Preparation of botanical extracts: The Plants selected as biopesticides used in the study such as Neem (*Azadirachta indica*), Garlic cloves (*Allium sativum* L.) and Black pepper (*Piper nigrum*). All the test plant materials were collected from locally available and processed. Plant material were washed and crushed. The paste was soaked in distilled water. The mixtures were filtered through muslin cloth and filtrates were used as stock solution and diluted to 5% and 10%. This method is commonly used followed by Isman, 2006 and Dubey., *et al.*, 2010. An aqueous extract and their mixtures were prepared in 1:1 ratio using method as adopted by Zaman *et al.*, 2012. The test plants material and mixtures were used.

The treatments details: The experiment included the following treatments:

(1.) T1 (2.) T2 (3.) T3 (4.) T4 (5.) T5 (6.) T6 (7.) T7 (8.) T0

Here T1=Neem leaves, T2=Garlic cloves, T3=Black pepper, T4= Neem leaves+ garlic cloves, T5= Neem leaves + Black pepper, T6= garlic cloves and black pepper, T7= Neem leaves + garlic cloves + black pepper and T0= control of no protectant.

Evaluation of impact of the treatments on the survival of 2nd instar larvae of DBM (Leaf dip bioassay technique)

The toxicity bioassay was conducted using a no-choice bioassay leaf dip method following Tabashnik *et al.* (1990). For the ingestion bioassay, unsprayed freshly excised Cabbage, *Brassica oleracea var. capitata* (Linn.) leaves were taken and small circular leaf discs of 8 cm (in diameter) were cut from them. The test leaf discs were dipped into respective extract concentrations of the bio-pesticides for 5-10 seconds and air dried for 1 hour at room temperature, a total seven bioassays were performed.

The obtained data were tabulated, and the DBM larval mortality was corrected using Abbott's formula (Abbot, W.S., 1925). Old cabbage leaf discs were replaced with fresh leaf discs of cabbage after every 48 hours. Abbott's formula was used to calculate the corrected percentage mortality for each treatment as follows:

Corrected Mortality =

$$\frac{(\% \text{ of larvae alive in control} - \% \text{ of larvae alive in treated})}{(\% \text{ of larvae alive in control})} \times 100$$

Evaluation of effects of treatment on the feeding behavior and antifeeding index (No-choice bioassays)

Bioassay experiments were conducted to assess the feeding behaviour and antifeedant index of larvae under no-choice conditions. The method was followed as described by Singh *et al.* (1982). Antifeedant Index (AFI) was also calculated by the formula given:

$$AFI = (C - T / C + T) \times 100$$

Here C is for leaf area consumed in control and T is for leaf area consumed by the larvae in treatment.

Development Period (3rd instar larvae of DBM)

The leaf dip method of bioassay following Tabashnik *et al.* (1990) was used to evaluate the efficacy of different concentrations of plant-based bio pesticides on the growth of 3rd instar larvae of *Plutella xylostella*. In the ingestion bioassay, unsprayed cabbage leaf discs (8 cm diameter) were dipped in the highest concentration of bio pesticides for each of the seven treatment combinations. After air dried at room temperature the treated leaf discs were placed on moist filter paper in petri dishes of 9 cm in diameter to prevent desiccation.

Results

Evaluation of impact of the treatments on the survival of 2nd instar larvae of DBM (Leaf dip bioassay technique)

The effect of different plant-based bio pesticides treatment on the mortality of second instar larvae

of DBM was studied under laboratory conditions using the leaf dip bioassay technique. The treatments include neem leaves (T1), garlic cloves (T2), black pepper (T3), neem + garlic (T4), neem + black pepper (T5), garlic + black pepper (T6) and neem + garlic + black pepper (T7) at different concentrations (2%, 4%, 6%, 8% 10% and 12%). (Table 1 and figure 1).

Table 1: Evaluation of impact of the treatments on the survival of 2nd instar larvae of DBM (Leaf dip bioassay technique)

Treatments	Mortality % of Larvae after treatment			
Dosage/100 ml	After-24 hrs	After-48 hrs	After-72 hrs	After-96 hrs
2%	20.00	16.66	23.33	37.50
4%	20.0	25.00	37.50	37.50
6%	10.71	28.57	39.28	48.33
8%	14.28	32.14	44.44	57.69
10%	21.43	35.71	48.15	58.33
12%	32.14	39.28	50.00	79.17
Control	0.00	0.00	0.00	0.00

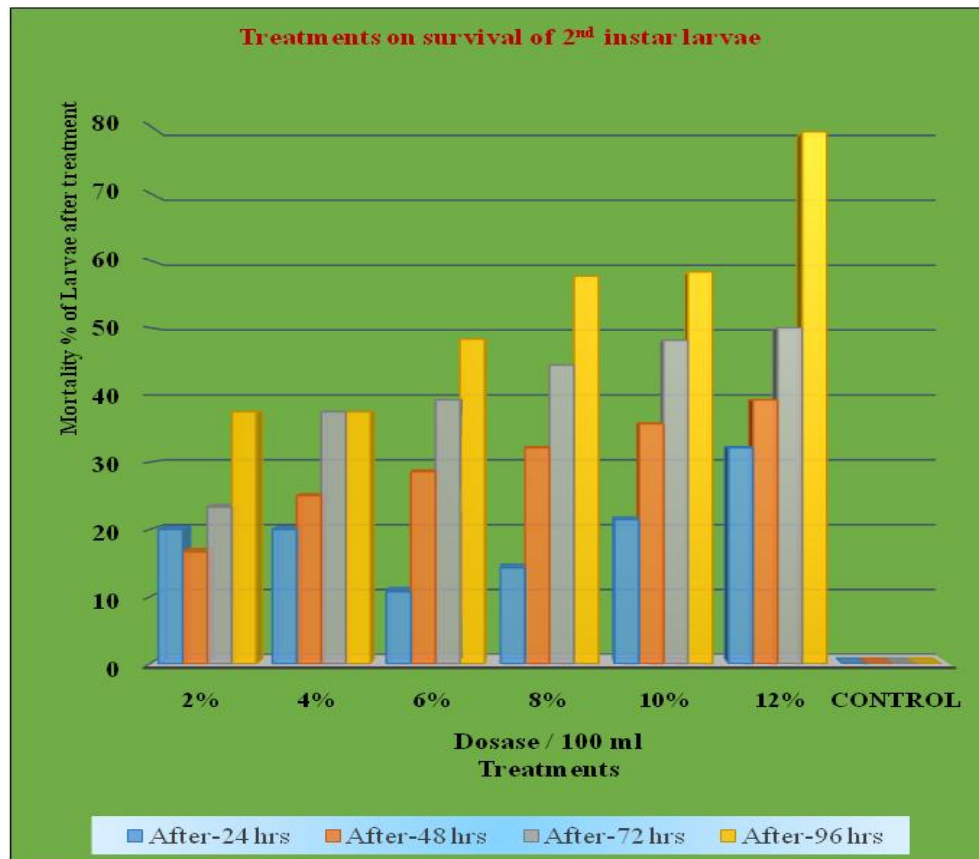


Figure 1. Impact of treatments on survival of 2nd instar larvae

Evaluation of effects of treatment on the feeding behavior and antifeeding index (No-choice bioassays)

The feeding response of second instar larvae of the DBM on cabbage leaf discs treated with aqueous extracts of different bio-pesticides showed considerable variation among treatments, T7 (Neem + Garlic + Black pepper) recorded the

lowest mean leaf area consumption (3.28 cm²) during the observation period (24-96 hrs), indicating the strongest feeding deterrent effect on larvae. This was followed by T5 (Neem + Black pepper) with a mean consumption of 4.18 cm², and T4 (Neem + Garlic) with 4.60 cm². These results clearly show that combined botanical extracts were more effective in reducing than individual plant extracts. (Table 2 and figure 2).

Table 2. Leaf area consumption by second instar larvae of DBM on cabbage leaf discs tread with aqueous extract of bio pesticides in no – choice bioassay

Treatments	Leaf area consumed (cm ²)				Mean (cm ²)
	24 hrs	48 hrs	72 hrs	96 hrs	
T1 (Neem)	3.20	5.10	6.40	7.00	5.43
T2 (Garlic)	4.00	6.80	8.50	9.30	7.15
T3 (Black pepper)	4.50	7.20	9.00	10.20	7.73
T4 (Neem +Garlic)	2.80	4.20	5.30	6.10	4.60
T5 (Neem+Black pepper)	2.50	3.90	4.80	5.50	4.18
T6 (Garlic+ Black pepper)	3.70	5.90	7.40	8.20	6.30
T7 (Neem+Garlic+Black pepper)	1.90	3.00	3.80	4.40	3.28
T8 (Control)	6.50	11.20	15.80	18.40	12.98

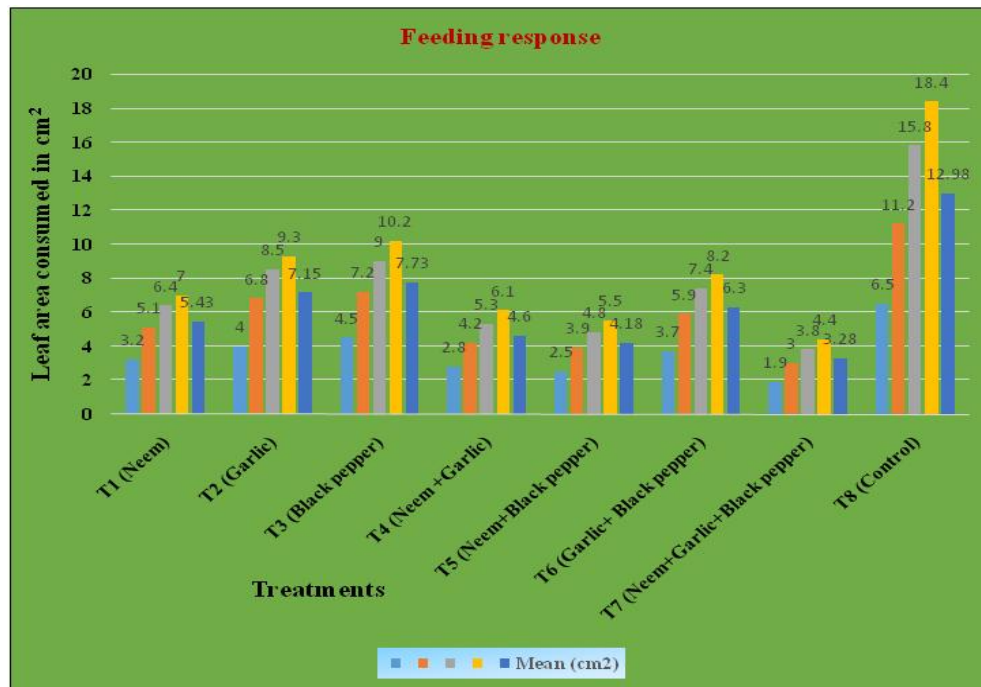


Figure 2. Leaf area consumption by second instar larvae of DBM on cabbage leaf discs tread with aqueous extract of bio pesticides in no – choice bioassay

Development Period (3rd instar larvae of DBM)

The effect on treatments on the larval duration of third and fourth instar of the DBM at the highest concentration (10%) is the result. This indicated that the control T8 recorded the minimum larval duration with 3.1 days for third instar and 2.5 days for the fourth instar, showing normal growth and development of the larvae in the absence of any treatment.

Among the treatments, Neem (T1) and Garlic (T2) recorded 3.8 and 3.7 days' duration in the

third instar and 4.8 and 4.9 days in the fourth instar, respectively. Black pepper (T3) showed comparatively lower prolongation in the third instar (3.2 days) but a longer duration in the fourth instar (4.6 days). The dual combination of treatments Neem + Black pepper (T5) recorded the maximum duration of the third instar (4.8 days) and triple combination, Neem + Garlic + Black pepper (T7) showed the maximum duration of the fourth instar (5.3 days). (Table 3 and figure 3).

Table 3. Effects of treatments on larval duration of 3rd instar of DBM at highest concentration

Treatments	concentration / 100 ml	3 rd Instar (days)	4 th Instar (days)
T1 (Neem)	10 %	3.8	4.8
T2 (Garlic)	10 %	3.7	4.9
T3 (Black pepper)	10 %	3.2	4.6
T4 (Neem +Garlic)	10 %	3.8	5.2
T5 (Neem+Black pepper)	10 %	4.8	5.0
T6 (Garlic+ Black pepper)	10 %	4.1	4.2
T7 (Neem+Garlic+Black pepper)	10 %	4.4	5.3
T8 (Control)	-	3.1	2.5

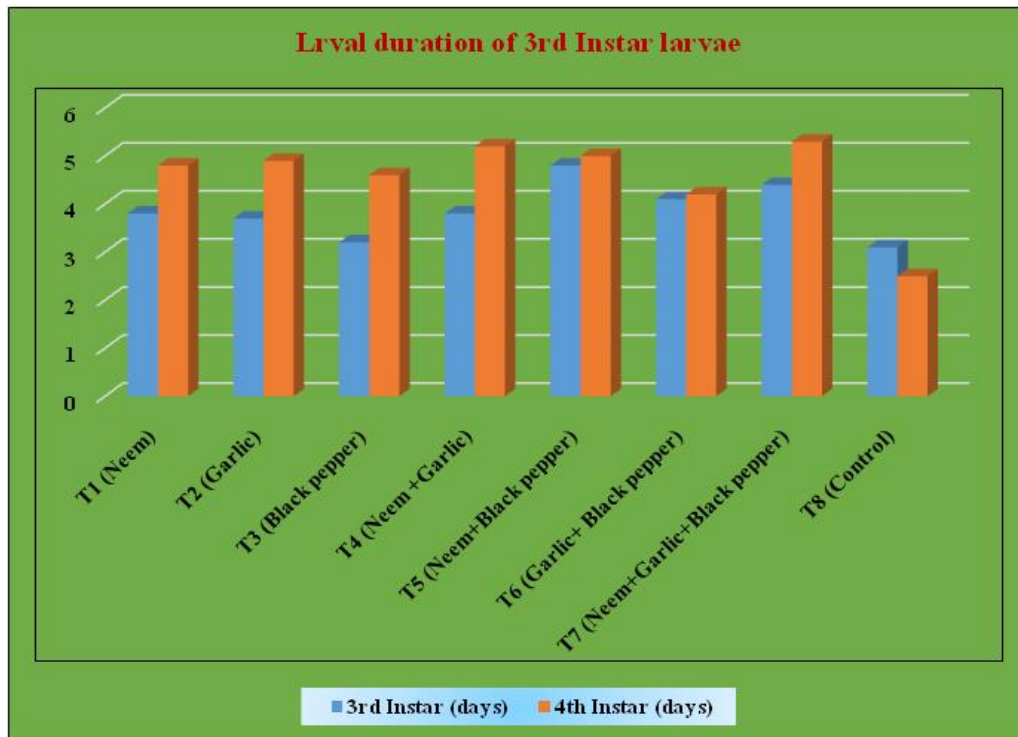


Figure 3. Effects of treatments on larval duration of 3rd instar of DBM at highest concentration

Antifeedant Index (AFI %) for aqueous extracts of biopesticides against second instar larvae of DBM

The antifeedant activity of different aqueous extracts of plant-based bio pesticides against second instar larvae of the DBM was assessed using the Antifeedant Index (AFI %). The results showed clear differences among treatments, indicating varying levels of feeding deterrence.

T7 (Neem + Garlic + Black pepper) recorded the highest antifeeding activity throughout the observations period (24 – 96 hrs), with a mean

AFI of 58.80%. The AFI values increased from 54.76% at 24 hrs to 61.43 % at 96 hrs, indicating a strong and persistent feeding deterrent effect on the larvae. Treatment proved to be the most effective in reducing feeding damage.

The second best treatment was T5 (Neem + Black pepper), which recorded a mean AFI of 50.05%, followed by T4 (Neem + Garlic) with 46.31% mean AFI. These treatments demonstrated that combinations involving neem significantly enhanced antifeedant activity compared to individual extracts (figure 4).

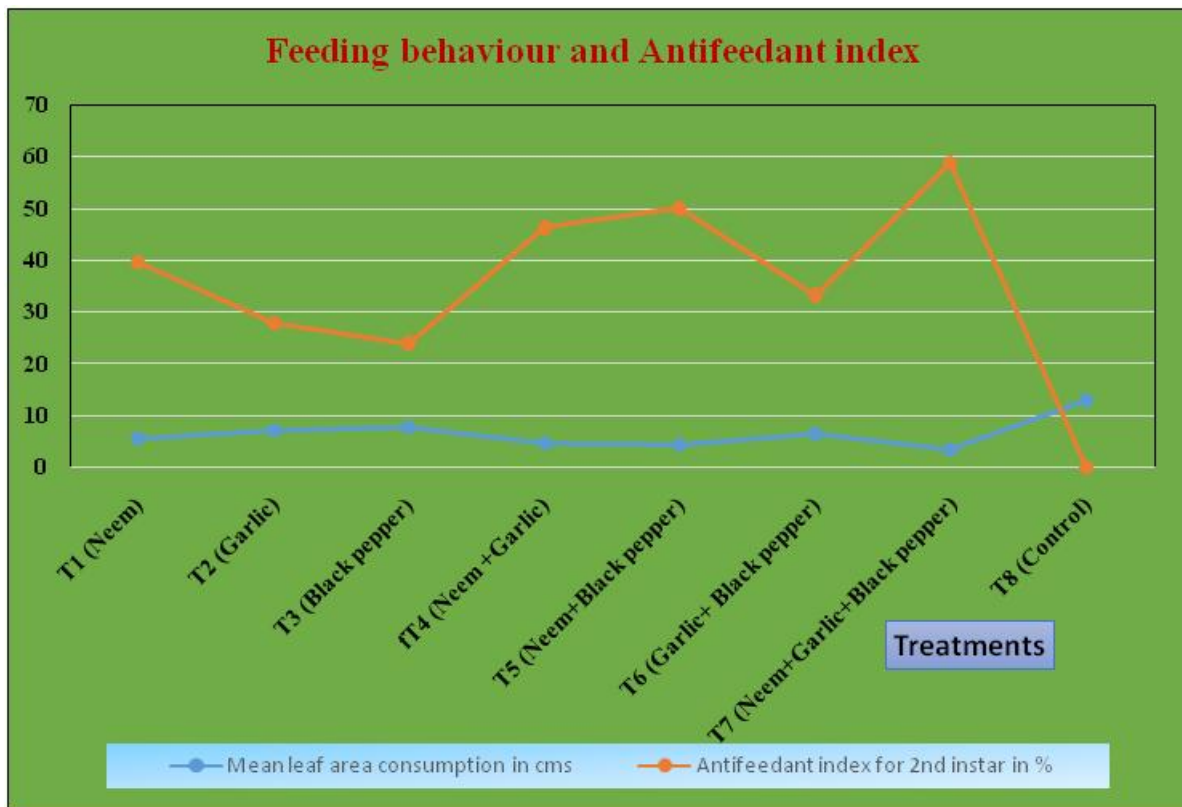


Figure 4. Impact of Feeding behaviour and Antifeedant index in no – choice bioassay



Plate 1: Larvae of *Plutella xylostella* on cabbage leaf



Plate 2: Cabbage leaf damage caused by larvae of *Plutella xylostella*



Plate 3: Antifeedant leaf disc no-choice bioassays

Discussion

The combined extract T7 (Neem + Garlic + Black pepper) showed the highest larval mortality. At higher concentrations, particularly 10% and 12%, the treatment recorded very high mortality, reaching 100% mortality after 96 hours. Overall, the results clearly demonstrated that combined plant extracts were more effective than individual extracts in causing larval mortality. The highest effectiveness was observed in the triple combination treatment (T7), followed by dual combinations (T4, T5 and T6), while individual treatments (T1, T2, and T3) showed relatively lower mortality.

These findings indicate that the combination of neem, garlic, and black pepper extracts has strong potential as an eco-friendly bio pesticide for the management of DBM in cabbage crop. Thus, the study clearly demonstrates that botanical combinations can serve as an effective eco-friendly pest management option for controlling larval feeding of *Plutella xylostella* in cabbage crops.

Conclusion

The present investigation was conducted to evaluate the efficacy of plant-based bio pesticides against the Diamondback Moth (DBM), *Plutella xylostella*, a major pest of cruciferous crops such as cabbage. Laboratory experiments were carried out to evaluate the effectiveness of botanical pest management practices against insect pests. Different treatments consisting of neem, garlic, black pepper and their combinations were tested at varying concentrations. Observations were recorded on larval mortality, feeding deterrence, growth and development parameters, pupal characteristics, and field population reduction. Botanical extracts, especially in combination can be effectively utilized for the management of pest in cabbage crops.

This plant-based biopesticides are biodegradable, less toxic to non-target organisms, suitable for integration into Integrated Pest Management

(IPM) programs and offers an eco-friendly as well as sustainable alternative to synthetic insecticides.

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