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# Biological control of cabbage (*Brassica oleracea*) pests in Bambili using leaf extract of neem (*Azadirachta indica*)

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## Abstract

Cabbage (*Brassica oleracea*), is an important vegetable crop cultivated and consumed in most parts of the world due to its rich nutritional, health and economic values. Cameroon's agricultural sector significantly depends on cabbage cultivation for food security and economic sustainability. Cabbage crops are often affected by pests that can significantly reduce both yield and quality. This study aimed at investigating the efficacy of different concentrations of neem (*Azadirachta indica*) leaf extract as a biological control strategy against cabbage pests in Bambili, Northwest region of Cameroon. Cabbage seeds were nursed in seedling trays and transplanted after four weeks of planting to the research plot of the University of Bamenda. Three neem leaf extract concentrations of 30g/5L, 60g/5L, and 90g/5L were prepared and sprayed on cabbage plants from the first to the fifth week after transplanting. Results obtained revealed that insect pests are greatest threats to cabbage growth. *Plutella xylostella*, *Hellula rogatalis*, and *Brevicoryne brassicae* were identified as the main pests. Higher concentration of 90g/5L of neem leaf extract was most effective and significantly reduced pest populations across all species studied resulting in greater yield. These findings underscored neem's potential as a sustainable biocontrol method for integrated pest management in agriculture.

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## Introduction

Cabbage (*Brassica oleracea*), is an important vegetable crop cultivated and consumed in most parts of the world due to its rich nutritional, health and economic values (Mageney et al, 2017). Rich in essential nutrients, cabbage is a low-calorie food source that provides vital vitamins such as vitamin C, vitamin K, and vitamin B6, along with minerals like manganese and potassium (Afrin et al., 2016). The cruciferous nature of cabbage also makes it a valuable source of phytochemicals, particularly glycosylates, which have been associated with potential anticancer properties and may contribute to overall health (Traka, 2016). These nutritional components contribute to the vegetable's role in supporting immune function, promoting bone health, and offering antioxidant protection against oxidative stress (Afrin et al., 2016).Moreover, cabbage has gained recognition for its potential health benefits beyond nutrition. Fermented cabbage products, such as sauerkraut and kimchi, are known for their probiotic content, offering a source of beneficial bacteria that can positively influence gut health and contribute to the maintenance of a balanced microbiota (Marco et al., 2017). The fermentation process enhances the bioavailability of nutrients and may also produce bioactive compounds with anti-inflammatory and antioxidant properties (Raffaella et al., 2010).

Cabbage is prone to pests and diseases, requiring effective pest management practices for successful growth (Ranieri et al., 2018). Furthermore, pests weaken cabbage plants, making them more susceptible to environmental stressors and diseases, further reducing yields (Zalucki et al., 2012).

Although chemical pesticides have traditionally been used to manage these pests, concerns about their negative impacts on human health and the environment have led to a search for safer alternatives.Pesticide exposure has been correlated with various acute and chronic health effects in agricultural labourers, rural communities, and consumers. Acute pesticide poisoning is a prevalent occupational hazard among farmworkers, manifesting in symptoms such as nausea, dizziness, respiratory distress, and neurological impairment (Vijendra, 2020). Chronic pesticide exposure has been linked to elevated risks of diverse health conditions, including cancer, neurological disorders, reproductive disorders, and respiratory ailments (Mostafalou and Abdollahi, 2017). Hence, advocating for safer and more sustainable pest management practices is imperative to safeguard both environmental and human health in agricultural systems.

The biological control of agricultural pests is gaining attraction as a sustainable alternative to chemical pesticides, which can be harmful to human health and the environment. Plant extracts have emerged as a promising solution due to their environmentally friendly properties and effectiveness in pest control. Neem leaf extract, known for its insecticidal qualities, has been extensively researched for its ability to manage a variety of pests. Neem formulations are effective against insects by interfering with their growth, development, and reproduction (Isman, 2006). This natural product contains bioactive compounds such as azadirachtin, which serves as a potent insect growth regulator and repellent (Mordue and Nisbet, 2000).

Studies have shown the efficacy of neem formulations against pests like the cabbage looper (*Trichoplusiani*), diamondback moth (*Plutella xylostella*), and cabbage aphid (*Brevicoryne brassicae*) (Hassan et al., 2016; Pavela, 2016).Neem is renowned for its potent natural pesticide properties, primarily derived from compounds like azadirachtin, which effectively combat a broad spectrum of pests including insects, nematodes, and fungi. Despite these, application methods, concentrations, and formulations of neem extract to maximize its effectiveness on different crops still remain underexplored.

Cameroon's agricultural sector significantly depends on cabbage cultivation for food security and economic sustainability, making innovations that improve cabbage yield and quality is crucial. This study aimed at investigating the efficacy of neem leaf extract as a pest management tool as well as identifying a suitable concentration that can repel insect damage and result in optimum growth and yield in cabbage, offering small-scale farmers in Cameroon, a bio-friendly alternative to conventional synthetic pesticides. By advocating for neem leaf extract as a bio pesticide, this study contributes to preserving Cameroon's rich biodiversity while fostering resilient and environmentally sustainable agricultural practices.

## Materials and methods

### Descriptions of the study area

Bambili is located in Tubah sub division, Mezam division North west region of Cameroon. It is located at latitude 5° 59′ 22″ north and longitude 10° 15′ 02″ east (Fig. 1). It has a subtropical highland climate with mild temperatures and abundant rainfall. The average annual temperature is 18.9 °C and the average annual precipitation is 2.029 mm and rain fall from mid-March to late October while the period between November to February is quite dry (IRAD report, 2020) Bambili is situated on a mountainous plateau at an elevation of 1.558 m above sea level. It is surrounded by hills and valleys, and has a scenic view of the Bambili Lake (Halvetas Cameroon, 2001) According to the 2005 census, Bambili had a population of 5.641 inhabitants.

### Nursery and seedling preparation

The seeds used were hybrid cabbage green coronet variety, obtained from a farmer’s shop in Bambili. Seedling trays filled with humid soil were used to nurse the cabbage seeds. The trays were place in a nursery with adequate sunlight to ensure maximum growth.

Seedlings were transplanted after 4 weeks of growth to the experimental plot. The experimental plot consisted of 4 ridges of 4m long by 1.22 m wide and 0.3m high. The distance between bridges was 0.5mon each ridge, 20 cabbage seedlings were planted on each ridge, making a total of 80 seedlings. The soil was fertilized with poultry manure three days before transplantation.

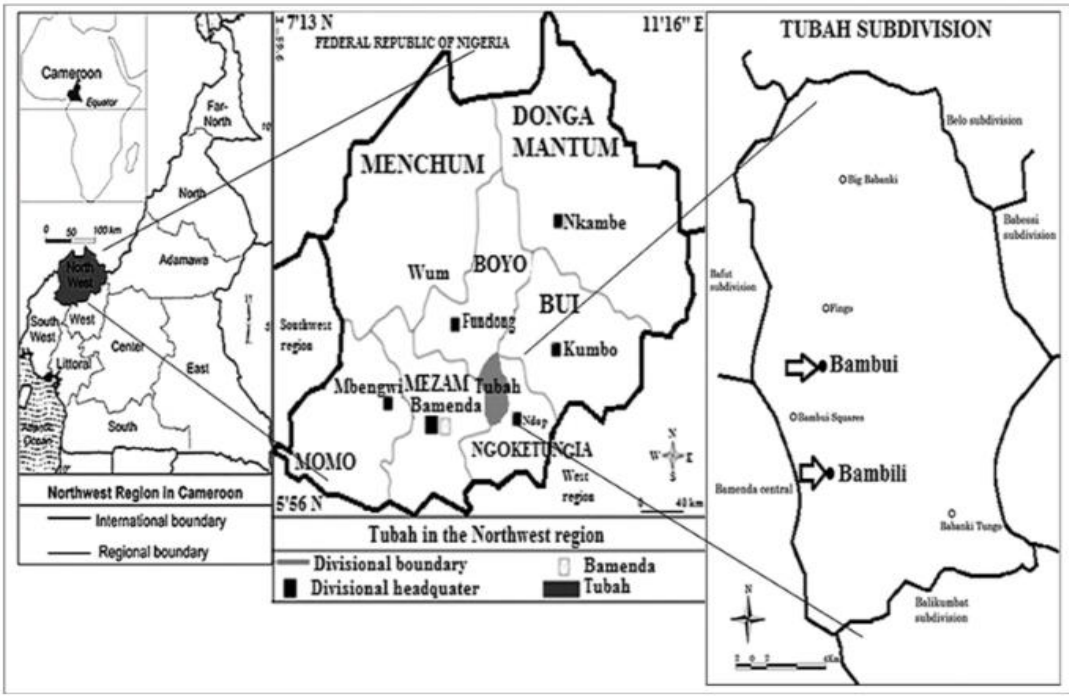


**Fig. 1:** The Geographical Location of Bambili. (Source: Ngwa and Fonjong, 2002a).

## Extraction of liquid from neem leaves

The extraction process was done using the protocol of Kumar and Navaratna (2018) and Rath et al., (2018). Healthy mature neem leaves were carefully harvested from neem trees using sharp scissors, ensuring minimal damage to the tree. The harvested leaves were then thoroughly washed under running water to eliminate any debris, dirt, or insects. Subsequently, the leaves were spread out in a well-ventilated area, shielded from direct sunlight, and left to air dry for approximately 2 weeks until they attained a crisp and brittle texture. Once fully dried, the neem leaves were finely ground into a powder using a grinder. In a clean basin, water and detergent were combined, with the detergent acting as a fixer. The neem leaf powder was then added to the solvent mixture, and the solution was stirred rigorously to facilitate extraction. This mixture was allowed to stand for 24 hours, with occasional stirring during this period. After the extraction duration elapsed, the solution underwent straining using a fine mesh strainer to eliminate any solid particles, resulting in the extraction of neem leaf extract in liquid form.


**Fig. 2:** Neem leaves extract preparation (a) Drying, (b) Grinding, and (c) Mixing.

## Pest identification and selection

Pest identification was done using the “sit and watch” approach once every week. Photographs of pest were taken during each visit and damages on cabbages noted. These pests were later identified using Insect Identification Database (BugGuide.net).

## Treatment application

Treatment consisting of different neem concentration were prepared:30 g/5L, 60 g/5L and 90 g/5L and a control. To each of the ridges, treatment application was done weekly for 5 weeks. This was done using a handheld sprayer, making sure to evenly distribute the extract on the leaves, stems, and surrounding soil.

## Data collection

Data on pest population was recorded by simple pest count, to evaluate the effectiveness of the neem leaf extract in controlling cabbage pests. This was done before and after the application of neem leaf extract. This process was repeated at regular intervals to monitor the pest population trend.

## Data analysis

Data was analyzed using the Statistical Package for Social Sciences (SPSS) to observe the inter correlation matrices on each pest per treatment. Pearson's correlation coefficient test was used to measure the strength and direction of the linear relationship between the treatments.

## Results

## Diversity of pest on cabbage

Seven species of insect pests and one fungi species were identified as pests on cabbage in Bambili. These are listed in Table 1.

**Table 1.** Diversity of pest on cabbage in Bambili.

| Order | Family | Species | Symptoms of pest damage |
|---|---|---|---|
| Homoptera | Aphididae | *Brevicoryne brassicae* (Cabbage aphids) | One of the most noticeable symptoms of cabbage aphid infestation is leaf curling additionally, the physical presence of aphids on the undersides of leaves lead to the distortion of leaf structures, affecting the overall appearance of the cabbage plant. Another consequence of cabbage aphid feeding is leaf yellowing. |
| Lepidoptera | Plutelidea | *Plutella xylostella* (Diamondback Moth) | A distinguishing symptom of diamondback moth infestation is the development of "shot-hole" patterns on cabbage leaves. The larvae of *P. xylostella* feed on leaf tissue, resulting in the creation of numerous small, irregularly shaped holes in the leaves as they consume the soft tissue between leaf veins. |
| | Crambidea | *Hellula rogatalis* | The larvae of *H. rogatalis* feed from within the seedpods of cabbage plants, they cause the seeds to shrivel, deform, or become completely destroyed. In addition to direct damage to seedpods, adult weevils also feed on other parts of the cabbage plant, including leaves and stems. |
| Orthoptera | Acrididea | *Nomadacris septemphfacia* | Locusts are voracious feeders capable of consuming large quantities of vegetation, including cabbage leaves. Their mandibles can shred and devour foliage, leading to significant defoliation of cabbage plants. |
| | Gryllidea | *Gryllus campestris* (Field Cricket) | Field crickets are omnivorous feeders and consume a wide range of plant material, including leaves, stems, and roots. Cricket feeding behaviour is such as they cut the whole stem of the cabbage plant disrupting completely the growth of the plant. |
| Stylommatophora | Arionidea | *Arion hortensis* | *Arion hortensis* causes considerable damage to cabbage plants through its feeding habits. These slugs gnaw large, irregular holes in the leaves and sometimes consuming entire seedlings. |
| | Helicidea | *Cornu aspersum* | Snails cause significant damage to cabbage plants by feeding on the leaves, creating irregular holes and leaving behind a slimy trail. |
| Peronosporales | Peronosporaceae | *Pseudoperonospora cubensis* (Downy mildew) | Symptoms of downy mildew displayed yellowish patches of discoloration on the upper surfaces of infected leaves. |

## Effect of different neem leaf extract concentrations on cabbage

Results revealed that plant infestation reduced drastically after application of leaf neem extract. Growth and yield improved as the plants were less infected. Different treatments showed different responses with regards to pest, growth and yield over time.

## Effect of neem leaf extract on *Brevicoryne brassicae*

*Brevicoryne brassicae* pests steadily increased over the five-week period in the control (T0), rising from 54 individuals in Week 1 to 80 individuals in Week 5. On the contrary, decrease in pest infestations were observed in all the other treatment ridges. T3 (90g/L) recorded the lowest pest number as compared to the other treatments (Table 2).

**Table 2.** Evolution *Brevicoryne brassicae* overtime.

| Species | Treatment | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 |
|---|---|---|---|---|---|---|
| *Brevicoryne brassicae* | T0 | 54 | 60 | 67 | 75 | 80 |
| | T1 | 58 | 55 | 53 | 50 | 45 |
| | T2 | 56 | 40 | 28 | 15 | 9 |
| | T3 | 60 | 45 | 30 | 18 | 7 |

## Effect of neem leaf extract on *Hellula rogatallis*

*Hellula rogatalis* pests recorded a rise over time in the control ridge from 5 individuals in Week 1 to 22 individuals in Week 5as compared to the other treatments that recoded a reduction in pest population over time (Table 3).The results suggest that neem leaf extract has a potential to control cabbage pests, with higher concentrations showing stronger effects. However, there might be a point where increasing the concentration beyond a certain threshold does not significantly improve the effectiveness of the treatment.

**Table 3.** Evolution *Hellula rogatallis* per treatment overtime.

| Species | Treatment | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 |
|---|---|---|---|---|---|---|
| *Hellula rogatallis* | T0 | 5 | 7 | 9 | 15 | 22 |
| | T1 | 14 | 13 | 11 | 9 | 5 |
| | T2 | 9 | 7 | 5 | 4 | 2 |
| | T3 | 10 | 8 | 7 | 7 | 4 |

**Table 4.** Evolution of *Plutella xylostella* per treatment overtime.

| Species | Treatment | Week 1 | Week 2 | Week 3 | Week 4 | Week 5 |
|---|---|---|---|---|---|---|
| *Plutella xylostella* | T0 | 14 | 19 | 21 | 22 | 27 |
| | T1 | 37 | 25 | 19 | 13 | 6 |
| | T2 | 17 | 11 | 6 | 5 | 3 |
| | T3 | 25 | 17 | 9 | 3 | 2 |

## Effect of neem leaf extract on *Plutella xylostella*

*Plutella xylostella* on the control ridge, devoid of neem leaf extract treatment, exhibited population counts of 14, 19, 21, 22, and 27 individuals per sample at weeks 1 to week 5, respectively. Nevertheless, the results underscored that the application of neem leaf extract at all concentrations (30g, 60g, and 90g) resulted in a reduction in the population of *Plutella xylostella* compared to the untreated control group.

Moreover, higher concentrations of neem leaf extract yielded more significant reductions in pest population, with the highest concentration (90g) achieving complete eradication by the end of the five-week period (Table 4).

## Comparison of the effect on different treatment concentrations on pest population

Overall analysis revealed that *P. xylostella* was the most sensitive pest to neem extract overtime while *H. rogatalis* was the most resistant pest to the treatment (Fig. 2). Generally, it was observed that after of neem extract, the insect pest drastically reduced. Significant differences were observed between all the treatments at $P \leq 0.05$.

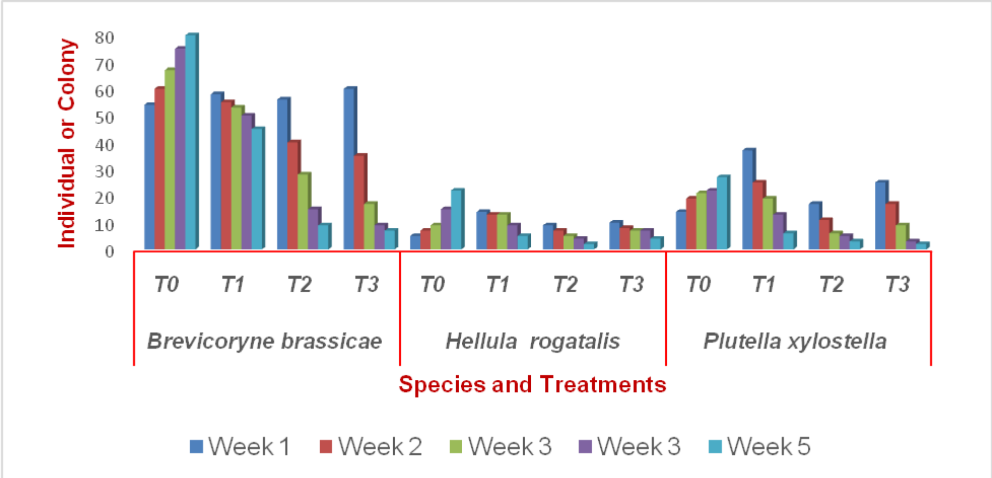


**Fig. 3:** Comparison of the effect on different treatment concentration on pest population.

## Inferential statistics

The correlation matrix for the different pests' treatment illustrates the relationships between different treatment groups: Control, 30g/5L, 60g/5 L, and 90g/5 L of neem leaf extract.

### Inter-item correlation matrix (*Brevicoryne brassicae* pest treatment)

The correlation matrix for *Brevicoryne brassicae* pest treatment reveals strong negative correlations between the control treatment and the various concentrations of neem leaf extract. The control treatment exhibited a perfect correlation with itself (1.000), as expected. However, its correlation with the 30g/5L treatment was -0.977, 60g/5L treatment was -0.992, and 90g/5L treatment was -0.996 (Table 5). The correlation between the 30g/5L treatment and the other treatments revealed a positive relationship, with a perfect correlation to itself (1.000), 0.956 with the 60g/5L treatment, and 0.973 with the 90g/5L treatment (Table 5). The 60g/5L and 90g/5L treatments exhibited very high positive correlations with each other (0.996), implying nearly identical effects on pest control. Both treatments also showed perfect correlation within themselves (1.000), indicating consistency (Table 5).

**Table 5.** Inter-item correlation matrix (*Brevicoryne brassicae* pest treatment).

| Treatments | Control | 30g/5 L | 60g/5 L | 90g/5 L |
|---|---|---|---|---|
| Control | 1.000 | | | |
| 30g/5 L | -0.977 | 1.000 | | |
| 60g/5 L | -0.992 | 0.956 | 1.000 | |
| 90g/5 L | -0.996 | 0.973 | 0.996 | 1.000 |

**Table 6.** Inter-item correlation matrix (*Hellula rogatalis* pest treatment).

| Treatments | Control | 30g/5 L | 60g/5 L | 90g/5 L |
|---|---|---|---|---|
| Control | 1.000 | | | |
| 30g/5 L | -0.993 | 1.000 | | |
| 60g/5 L | -0.940 | 0.962 | 1.000 | |
| 90g/5 L | -0.904 | 0.919 | 0.986 | 1.000 |

### Inter-item correlation matrix (*Hellula rogatalis* pest treatment)

The correlation matrix for the *Hellula rogatalis* pest treatment illustrates the relationships between different treatment groups. The negative correlations between the control group and the neem treatments (-0.993, -0.940, and -0.904) suggest an inverse relationship. The strongest inverse relationship was observed between the control and the 30g/5L treatment (-0.993) (Table 6). Positive correlations among the neem extract treatments (ranging from 0.919 to 0.986) highlighted a consistent effect of neem on pest control across different concentrations. The highest correlation (0.986) was between the 60g/5L and 90g/5L treatments (Table 6).

### Inter-item correlation matrix (*Plutella xylostella* pest treatment)

The inter-item correlation matrix for *Plutella xylostella* pest treatment offers a detailed insight into the relationships between different treatment concentrations of neem leaf extract and the control group. This matrix aids in understanding how various treatment levels correlate with each other and with the untreated control, providing insights into the consistency and potential effectiveness of the treatments.

The control treatment revealed a perfect correlation with itself, as expected (1.000). However, its correlations with the neem treatments are highly negative: -0.984 with 30g/5 litres, -0.950 with 60g/5 litres, and -0.931 with 90g/5 litres. These negative values indicate that as the concentration of neem leaf extract increases, the likelihood of pest population or damage decreases, suggesting the effectiveness of the treatments compared to the control. The correlations between different neem extract concentrations are all positive and close to 1. For instance, 30g/5 litres and 60g/5 litres have a correlation of 0.978, 30g/5 litres and 90g/5 litres have a correlation of 0.979, and 60g/5 litres and 90g/5 litres have a correlation of 0.984. These high positive correlations imply a consistent pattern in how these treatments affect the pest, indicating that all concentrations are similarly effective, although there may be slight variations in their impact.

The negative correlations between the control and treatment groups suggest that neem leaf extract is effective in reducing the presence or impact of *Plutella xylostella* pests on cabbage. The high positive correlations among the different concentrations of neem extract indicate that increasing the concentration does not significantly alter the relationship between the treatments, suggesting that even the lowest concentration (30g/5 L) could be nearly as effective as the higher concentrations. This consistency in treatment efficacy can assist in recommending the most cost-effective and environmentally friendly concentration for practical agricultural use.

**Table 7.** Inter-Item Correlation Matrix (*Plutella xylostella* pest treatment).

| Treatments | Control | 30g/5 L | 60g/5 L | 90g/5 L |
|---|---|---|---|---|
| **Control** | 1.000 | | | |
| **30g/5 L** | -0.984 | 1.000 | | |
| **60g/5 L** | -0.950 | 0.978 | 1.000 | |
| **90g/5 L** | -0.931 | 0.979 | 0.984 | 1.000 |

### Effect of neem extract on yield of cabbage

Result on yield based on the T1, T2, T3, and T4 revealed that highest yield was observed on cabbages applied with high neem extract (90 g) while the least yield was observed with the ridge applied with (30 g) (Fig. 4). The control ridge showed the least yield. These results infer that high neem extract concentration has high pesticide effect on cabbage growth thus reducing pest and increasing yield in cabbage. Significant differences were observed between all the treatments at $P \leq 0.05$.

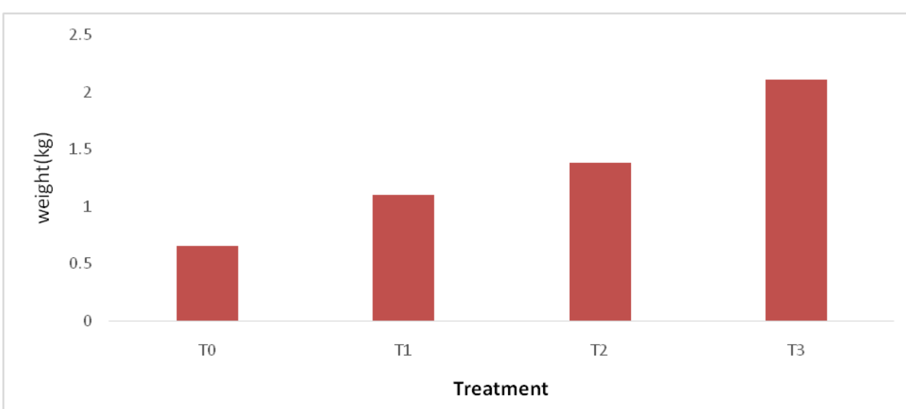


**Fig. 4:** Variation of weight per treatment.

## Discussion

The diversity of pests infesting cabbage in Bambili encompasses various orders and families, presenting a broad spectrum of ecological interactions and challenges for pest management. Within the Homoptera order, the Aphididae family, specifically *Brevicoryne brassicae*, poses a significant threat to cabbage by causing damage through sap-sucking, stunting growth, and transmitting plant viruses. Past studies, such as those by Blackman and Eastop (2000), underscore the widespread impact of aphids on brassicas globally. The Lepidoptera order includes pests from *the Plutelidea* and Crambidea families, such as *Plutella xylostella* and *Hellula rogatalis*, known for their voracious larval feeding on cabbage leaves, often resulting in severe defoliation. This aligns with findings of Machekano et al. (2019), who identified *Plutella xylostella* as a notorious global brassica pest.

The findings of the current study underscore the highly effective role of neem leaf extract in controlling *Brevicoryne brassicae* pests on cabbage, aligning with previous research emphasizing neem's pesticide properties. The inter-item correlation matrix revealed that as the concentration of neem extract increased from 30g/5 litres to 90g/5 litres, the effectiveness in pest control also increased, as indicated by the strong negative correlations with the control group. This observation is consistent with findings of Schmutterer (2002), who demonstrated that neem-based treatments significantly reduce pest populations across various agricultural settings. The high positive correlations between different treatment concentrations in our study further confirm the consistency and reliability of neem extract as an effective pest control agent, supporting earlier research by Isman (2006), which highlighted neem's broad-spectrum pesticide activities and its potential for integration into pest management programs.

Furthermore, the study's results underline neem extract's suitability for sustainable agriculture, echoing the conclusions of Stoll (2000), who advocated for the use of botanical pesticides in reducing chemical pesticide reliance. The strong efficacy of neem extract in our study suggests it could serve as a viable alternative to synthetic pesticides, which often lead to resistance and environmental concerns. This aligns with the work of Mordue and Nisbet (2000), who found that neem's complex mode of action reduces the likelihood of pest resistance. Additionally, our findings resonate with the practical implications highlighted by Thacker et al. (2003), emphasizing neem's role in integrated pest management (IPM) systems, offering an environmentally friendly solution with reduced non-target effects. Therefore, this study not only reinforces neem's pest control effectiveness demonstrated in past studies but also contributes to the ongoing discourse on sustainable agricultural practices and the importance of eco-friendly pest management strategies.

The findings of this study indicate that neem leaf extract is an effective biological control agent against *Hellula rogatalis* pests on cabbage. The negative correlations between the control and neem treatments suggest a significant reduction in pest populations with the application of neem extract, supporting its efficacy. The strong positive correlations among different concentrations of neem extract (30g/5 L, 60g/5 L, and 90g/5 L) indicate similar effectiveness across these concentrations. This aligns with previous research which has demonstrated the insecticidal properties of neem. For instance, studies by Sharma et al. (2021) and Isman (2006) reported that neem extracts significantly reduce pest populations by disrupting their growth and reproduction cycles. The presence of azadirachtin, a key compound in neem, is known for its antifeedant and growth-inhibiting properties, which corroborates our findings of its consistent effectiveness across varying concentrations.

## Conclusions

The findings of this study indicate that neem leaf extract is highly effective in controlling *Plutella xylostella* pests on cabbage crops. The negative correlations between the control group and the various concentrations of neem extract suggest a significant reduction in pest presence and damage with the application of neem. This aligns with past research that has demonstrated the insecticidal properties of neem. For instance, a study of Schmutterer (2002) highlighted neem's broad-spectrum efficacy against a variety of pests, including lepidopteran larvae like *Plutella xylostella*, by disrupting their growth and feeding behaviours. The current study corroborates these findings, showing that even the lowest concentration tested (30 g/5 L) effectively reduces pest activity, which is consistent with previous results indicating that neem extracts are potent even at lower concentrations.

## Conflict of interest statement

Authors declare that they have no conflict of interest.

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