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Research Article

Insecticidal activity of *Azadirachta indica* A. Juss. and *Jatropha curcas* L. seed oils against cutworm *Agrotis ipsilon* (Hufnagel, 1766) (Lepidoptera: Noctuidae) on cabbage *Brassica oleracea* L.

Vou M. Shutt[1], Diana U. Affiah[2], Gavou Yakubu[1], John S. Gushit[1]

[1]University of Jos, Plateau, Nigeria [2]Universidade Estadual do Norte Fluminense Darcy Ribeiro, Campos dos Goytacazes, RJ, Brazil.
Corresponding author: dianaaffiah@gmail.com

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Abstract. Cutworms *Agrotis ipsilon* (Hufnagel, 1766) (Lepidoptera: Noctuidae) are destructive pests of cabbage *Brassica oleracea* L. (Brassicaceae) and other cruciferous crops, causing severe yield losses by feeding on seedlings and young plants. Excessive use of synthetic pesticides has contributed to resistance development, environmental contamination, and health risks. In response, botanical insecticides have therefore gained increasing attention as sustainable pest control alternatives. This study evaluated the insecticidal efficacy of neem *Azadirachta indica* A. Juss. (Meliaceae) and physic nut *Jatropha curcas* L. (Euphorbiaceae) seed oils against cutworm larvae collected from cabbage farms in Jos North Local Government Area, Plateau State, Nigeria. Seed oils were extracted using Soxhlet extraction with n-hexane and evaluated using a leaf disc ingestion bioassay at concentrations of 15%, 30%, and 60%. A synthetic insecticide (Moran® 30) and distilled water served as positive and negative controls respectively. Mortality was monitored for 72 h. Neem seed oil produced the highest mortality at 60% concentration, achieving complete larval mortality within 24-48 h. Physic nut oil also exhibited notable insecticidal activity, but slightly lower efficacy when compared with neem oil. The statistical analysis revealed significant differences among treatments when comparing the botanical insecticides with the positive and negative control ($P < 0.05$). The study demonstrates that botanical oils can serve as effective alternatives to synthetic insecticides for cutworm management in cabbage production systems.

Keywords: Lepidoptera pest, Neem oil, Physic nut, Botanical insecticide, Cruciferous crop, Larval mortality.

Introduction

Cabbage *Brassica oleracea* L. (Brassicaceae) is an economically important vegetable crop widely cultivated throughout the world (Rijal et al. 2026). It serves as an important source of vitamins, minerals and dietary fiber. It contributes greatly to food security and farm income in many developing countries (Rijal et al. 2026). Cabbage production faces several biotic constraints, particularly insect pests that significantly reduce yield and crop quality (Ofuya et al. 2023).

Cutworms *Agrotis ipsilon* (Hufnagel, 1766) (Lepidoptera: Noctuidae) are considered the most destructive pests because they feed on seedlings and sever plant stems near the soil surface (Sapkota et al. 2021). This feeding behavior often results in complete plant mortality, severe economic and yield losses for farmers (Sapkota et al. 2021). Globally, insect pests can cause yield losses between 50-90% in cruciferous vegetables when control measures are not applied (Ofuya et al. 2023; Hasan et al. 2025).

Traditionally, farmers rely heavily on synthetic insecticides for pest management (Ahmed et al. 2022). However, over-reliance on chemical pesticides has created several problems which include development of chemical insecticide resistance, environmental pollution, toxicity to non-target organisms, and health hazards to farmers and consumers (Zhou et al. 2025). Recent research has focused on environmentally friendly pest control strategies such as botanical insecticides (Haritha et al. 2021; Shang et al. 2024).

Botanical insecticides are derived from plants and contain bioactive compounds that exhibit insecticidal, antifeedant, repellent, or growth-regulating properties (Rawat et al. 2024). Extracts from plants such as *Azadirachta indica* A. Juss. (Meliaceae) (neem) and *Jatropha curcas* L. (Euphorbiaceae) (physic nut) contain bioactive compounds with insecticidal properties. Neem contains azadirachtin, which acts both as an antifeedant and a growth regulator that disrupts molting and reproduction of these insect (Almadiy et al. 2025), while physic nut, according to Muniz et al. (2020) and Alharbi & Alanazi (2024), contains phorbol esters, which has been demonstrated to possess toxic and insect-repellent properties. Valdez-Ramirez et al. (2023) in a previous study demonstrated the effectiveness of these botanical extracts against various insect pests including *Plutella xylostella* (Linnaeus, 1758) (Lepidoptera: Plutellidae) and *Spodoptera* Guenée, 1852 (Lepidoptera: Noctuidae) species.

There is limited information regarding the effectiveness of neem and physic nut seed oils evaluated under on-farm field conditions within Nigerian cabbage cultivation systems. The objective of this study is to evaluate the insecticidal activity of neem and physic nut seed oils against cutworm larvae collected from cabbage farms in Jos North Local Government Area of Plateau State, Nigeria.

Material and Methods

Study area. The study was carried out in Jos North Local Government Area of Plateau State, Nigeria, with field surveys conducted across ten unsprayed cabbage farms located in Farin Gada, Naraguta Village, and Lamingo Dam.

Cutworm collection and rearing. Cutworm larvae were collected from infested cabbage plants using a camel brush into well labelled plastic containers and transported to the Laboratory. The larvae were carefully maintained at an optimal temperature of 25-27 °C, relative humidity of 70-80%, and a 12:12 h light:dark photo period. Fresh, healthy leaves of cabbage, free from pesticide residues, were utilized as feed and fed to the larvae three times daily.

Botanical extracts preparation. Dried seeds of neem and physic nut were pulverized, weighed (290 g) and subjected to Soxhlet extraction using n-hexane (350 mL) as solvent. The extracted oil was separated using a rotary evaporator to remove the solvent and obtain pure seed oil extracts.

Synthetic insecticide preparation. Moran® 30 insecticide, a water-dispersible granule (WG) formulation containing indoxacarb 300 g/kg (30% w/w) and manufactured by Shandong Weifang Rainbow Chemical Co., Ltd., was used as the positive chemical control. This was prepared by diluting 3.5 mL Moran® 30 in sterile distilled water to get 1,500 mL solution.

Larvicidal bioassay. Leaf disc bioassay method was adapted from Ogbonna et al. (2016). Leaf disc bioassays were conducted using untreated cabbage leaves (5 cm diameter). The leaves were treated as shown in Tab. 1. Dilutions of neem and physic nut extracts were prepared using distilled water with Tween 20 as an emulsifying agent. Ten cutworm larvae were introduced into well-labelled Petri dishes containing treated leaf discs. Mortality was monitored up to 72 h following exposure, with larvae classified as dead when they failed to respond to gentle probing.

Table 1. Leaves treatments for larvicidal bioassay of neem *Azadirachta indica* A. Juss. (Meliaceae) and physic nut *Jatropha curcas* L. (Euphorbiaceae) seed oils against cutworm *Agrotis ipsilon* (Hufnagel, 1766) (Lepidoptera: Noctuidae) on cabbage *Brassica oleracea* L. (Brassicaceae).

Treatment	Concentration
Neem oil	15%
Neem oil	30%
Neem oil	60%
Physic nut oil	15%
Physic nut oil	30%
Physic nut oil	60%
Moran® 30	Positive control
Distilled water + Tween 20	Negative control

Experimental design and statistical analysis. The experiment followed a completely randomized design, with eight treatments (Tab. 1) and three replications. Each Petri dish containing ten cutworm larvae was considered a replication. In total, 24 treatment units were established, including both positive and negative controls.

Mortality data were subjected to two-way analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) to determine treatment differences. In addition, probit regression models were fitted using R software version 4.4.1 (R Core Team 2026) to estimate median lethal concentrations (LC_{50}) and median lethal times (LT_{50}) for neem and physic nut treatments. Standard errors (SEs) derived from the probit models were used to calculate 95% confidence intervals (CIs), ensuring the robustness of both LC_{50} and LT_{50} estimates. Statistical significance was determined at the threshold of $p \leq 0.05$

Results

Neem seed oil induced a rapid, dose-dependent mortality in cutworm larvae, achieving 100% mortality across all tested concentrations (15%, 30%, 60%) before 72 h post-exposure (Tab. 2). The 60% concentration reached maximum efficacy earliest, at 14 h (100% mortality), followed by 30% concentration at 22 h (100% mortality). The 15% concentration achieved full mortality more gradually, requiring approximately 26 h (100% mortality). The positive control showed delayed lethality, attaining 100% mortality only at 72 h, while the negative control exhibited 0% mortality throughout the period of the exposure. Statistical analysis (ANOVA) confirmed significant differences from the negative control ($p < 0.05$), with all active treatments converging at 100% mortality.

Physic nut seed oil demonstrated a clear dose- and time-dependent mortality in cutworm larvae, with mean cumulative mortality (± SE) reaching 100% across all concentrations (15%, 30%, 60%) well before 72 h post-exposure (Tab. 3). At 16 h, the 60% concentration achieved complete mortality (100%), while 30% reached 100% mortality at 20 h and 15% at 28 h. In contrast, the positive control exhibited slower lethality, attaining 100% mortality only at 72 h, while the negative control showed no activity (0%) throughout the period of the exposure. Statistical groupings (a, b) indicate treatments significantly outperformed the negative control ($p < 0.05$), with no differences among active treatments.

Table 2. Mortality (mean %±SE) of cutworm *Agrotis ipsilon* (Hufnagel, 1766) (Lepidoptera: Noctuidae) larvae fed on cabbage *Brassica oleracea* L. (Brassicaceae) leaf discs treated with neem *Azadirachta indica* A. Juss. (Meliaceae) seed oil*.

Time (h)	Positive control[1]	Negative control[2]	Oil concentrations		
			15%	30%	60%
1	0±0.00b	0±0.00b	3.30±0.58b	6.70±0.58a	10±0.00a
2	0±0.00b	0±0.00b	10±1.00a	13.30±0.58a	23.30±1.15a
4	3.30±0.58a	0±0.00b	13.30±0.58a	16.70±0.58a	46.70±0.58a
6	6.70±0.58a	0±0.00b	16.70±0.58a	20±0.00a	63.30±0.58a
8	6.70±0.58a	0±0.00b	20±0.00a	43.30±0.58a	73.30±0.58a
10	10±0.00a	0±0.00b	36.70±0.58a	50±1.00a	80±1.00a
12	10±0.00a	0±0.00b	43.30±0.58a	66.70±0.58a	90±0.00a
14	10±0.00a	0±0.00b	63.30±0.58a	73.30±0.58a	**100±0.00a**
16	10±0.00a	0±0.00b	73.30±0.58a	76.70±0.58a	100±0.00a
18	13.30±0.58a	0±0.00b	76.70±0.58a	86.70±0.58a	100±0.00a
20	13.30±0.58a	0±0.00b	83.30±0.58a	90±0.00a	100±0.00a
22	16.70±0.58a	0±0.00b	86.70±0.58a	**100±0.00a**	100±0.00a
24	16.70±0.58a	0±0.00b	90±0.00a	100±0.00a	100±0.00a
26	20±0.00a	0±0.00b	**100±0.00a**	100±0.00a	100±0.00a
28	23.30±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
30	23.30±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
32	23.30±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
34	23.30±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
36	26.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
38	26.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
40	26.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
42	33.30±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
44	33.30±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
46	36.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
48	40±0.00a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
50	40±0.00a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
52	50±1.00a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
54	53.30±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
56	56.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
58	63.30±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
60	66.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
62	66.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
64	66.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
66	76.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
68	80±0.00a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
70	90±0.00a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
72	**100±0.00a**	0±0.00b	100±0.00a	100±0.00a	100±0.00a

*Means with different letters along each line indicate significant difference at $p \leq 0.05$ among the treatments; [1]Moran® 30; [2]Distilled water + Tween 20.

Table 3. Mortality (mean %±SE) of cutworm *Agrotis ipsilon* (Hufnagel, 1766) (Lepidoptera: Noctuidae) larvae fed on cabbage *Brassica oleracea* L. (Brassicaceae) leaf discs treated with physic nut *Jatropha curcas* L. (Euphorbiaceae) seed oil. *

Time (h)	Positive control[1]	Negative control[2]	Oil concentrations		
			15%	30%	60%
1	0±0.00b	0±0.00b	0±0.00b	3.30±0.58a	6.70±0.58a
2	0±0.00b	0±0.00b	13.30±0.58a	10±1.00a	26.70±0.58a
4	3.30±0.58a	0±0.00b	13.30±0.58a	20±1.00a	36.70±0.58a
6	6.70±0.58a	0±0.00b	16.70±0.58a	33.30±0.58a	46.70±0.58a
8	6.70±0.58a	0±0.00b	30±0.00a	50±1.00a	66.70±0.58a
10	10±0.00a	0±0.00b	33.30±0.58a	63.30±0.00a	76.70±0.58a
12	10±0.00a	0±0.00b	50±0.00a	70±0.00a	86.70±0.58a
14	10±0.00a	0±0.00b	53.30±0.58a	76.70±0.58a	90±0.00a
16	10±0.00a	0±0.00b	63.30±0.58a	83.30±0.58a	**100±0.00a**
18	13.30±0.58a	0±0.00b	73.30±0.58a	90±0.00a	100±0.00a
20	13.30±0.58a	0±0.00b	86.70±0.58a	**100±0.00a**	100±0.00a
22	16.70±0.58a	0±0.00b	86.70±0.58a	100±0.00a	100±0.00a
24	16.70±0.58a	0±0.00b	93.30±0.58a	100±0.00a	100±0.00a
26	20±0.00a	0±0.00b	93.30±0.58a	100±0.00a	100±0.00a
28	23.30±0.58a	0±0.00b	**100±0.00a**	100±0.00a	100±0.00a
30	23.30±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
32	23.30±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
34	23.30±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
36	26.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
38	26.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
40	26.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
42	33.30±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
44	33.30±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
46	36.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
48	40±0.00a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
50	40±0.00a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
52	50±0.00a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
54	53.30±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
56	56.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
58	63.30±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
60	66.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
62	66.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
64	66.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
66	76.70±0.58a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
68	80±0.00a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
70	90±0.00a	0±0.00b	100±0.00a	100±0.00a	100±0.00a
72	**100±0.00a**	0±0.00b	100±0.00a	100±0.00a	100±0.00a

*Means with different letters along each line indicate significant difference at $p \leq 0.05$ among the treatments; [1]Moran® 30; [2]Distilled water + Tween 20.

Probit regression analysis of dose response data demonstrated that both neem and physic nut seed oil extracts were highly effective against *A. ipsilon* larvae. Median lethal concentration (LC_{50}) values were estimated at 9.31% (95% CI: 7.47-11.14%) for neem and 9.02% (95% CI: 7.26-10.78%) for physic nut, with overlapping confidence intervals indicating comparable potency. In terms of speed of action, neem oil achieved a shorter median lethal time (LT_{50}) of 24.5 h compared to 30.2 h for physic nut, reflecting faster larval mortality. The confidence intervals for both LC_{50} and LT_{50} estimates confirmed statistical reliability, and overall results suggest that neem oil not only requires lower concentrations but also acts more rapidly, making it a more effective botanical alternative for cutworm management in cruciferous cropping systems.

Probit analysis of dose-response data from both neem and physic nut seed oil extracts were highly effective against cutworm larvae achieving median lethal concentration (LT_{50}) values of 9.31% (95% CI: 7.47–11.14 %) for neem and 9.02% (95% CI: 7.26–10.78%) for physic nut (Tab. 4). The CI intervals indicated that the two treatments were statistically comparable in potency.

Mean cumulative mortality of cutworm larvae increased progressively across time points (24, 48, 72 h) for all active treatments (Fig. 1). Both neem (15-60%) and physic nut (15-60%) seed oils achieved near complete mortality by 24 h (9.67 and 9.78, respectively), reaching maximum values (10) at 48 h. The positive control exhibited delayed efficacy (1.67 at 24 h, 4 at 48 h, 10 at 72 h), while the negative control showed no mortality (0) throughout.

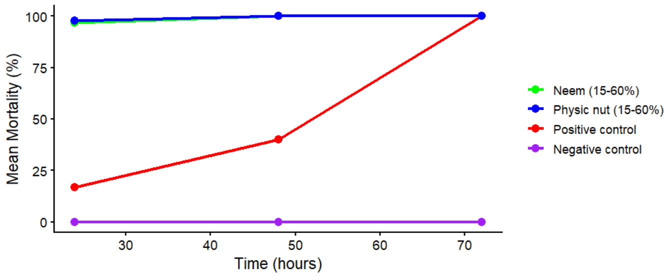

Figure 1. Trend in mean mortality response of cutworm *Agrotis ipsilon* (Hufnagel, 1766) (Lepidoptera: Noctuidae) larvae at 24, 48, and 72 hours following exposure to both neem *Azadirachta indica* A. Juss. (Meliaceae) and physic nut *Jatropha curcas* L. (Euphorbiaceae) seed oil extracts on treated cabbage *Brassica oleracea* L. (Brassicaceae) leaf discs at mean concentrations of 15%, 30%, and 60%, compared with positive and negative controls.

Discussion

Neem seed oil demonstrated superior insecticidal potency against cutworm larvae when compared to both positive and negative control. This aligns with recent reports confirming the insecticidal properties of neem (Sapkota et al. 2021; Ofuya et al. 2023). Studies on *Spodoptera frugiperda* (J.E. Smith, 1797) (Lepidoptera: Noctuidae) demonstrated that neem-based formulations significantly reduce larval survival, feeding, and growth, with efficacy increasing dose-dependently (Acharya et al. 2023). Similarly, aqueous seed extracts elevate larval mortality in *Bombyx mori* L., 1758 (Lepidoptera: Bombycidae) by inhibiting detoxification enzymes like esterases and carboxylesterases, underscoring toxico-dynamic impacts on Lepidoptera (Rattanapan et al. 2025). Research on *Anticarsia gemmatalis* Hübner, 1818 (Lepidoptera: Erebidae) shows neem oil decreases adult emergence and boosts larval mortality across concentrations, with higher doses hastening lethality (Mourão et al. 2014). Beyond Lepidoptera, neem seed extracts have also shown to exhibit broad activity against Diptera (*Anopheles* spp.) and Coleoptera [*Acanthoscelides obtectus* (Say, 1831) (Chrysomelidae)], affirming their biopesticide versatility (Ayinde et al. 2020; Lama et al. 2022; Karakaş 2023). The rapid larval mortality observed at higher concentrations in this study can be attributed to azadirachtin, the primary active compound in neem, which exerts its effects through multiple modes of action including feeding deterrence,

Table 4. Lethal concentration (LC_{50}) and lethal time (LT_{50}) estimates (hours) and 95% confidence intervals (CIs) for neem *Azadirachta indica* A. Juss. (Meliaceae) and physic nut *Jatropha curcas* L. (Euphorbiaceae) seed oils against cutworm *Agrotis ipsilon* (Hufnagel, 1766) (Lepidoptera: Noctuidae) larvae fed on cabbage *Brassica oleracea* L. (Brassicaceae) treated leaf discs

Treatment	LC_{50}	Lower CI 95	Upper CI 95	LT_{50} (hours)	Lower CI 95	Upper CI 95
Neem	9.30645849	7.47481518	11.1381018	24.5	20.3	28.7
Physic nut	9.02097137	7.26394579	10.7779969	30.2	25.1	35.4

disruption of molting and growth processes, and direct toxicity (Almadiy et al. 2025). Importantly, while concentration determined the speed of kill, the eventual convergence at 100% mortality across all treatment's underscores neem's reliability as a lethal agent against cutworm.

The rapid, concentration-dependent mortality demonstrates that physic nut seed oils possess a potent insecticidal activity against cutworm larvae (Alharbi & Alanazi 2024). This is likely due to the presence phorbol esters and other bioactive compounds that disrupt feeding, gut physiology, and molting (Alharbi & Alanazi 2024). This was similar to that observed with neem seed oil in this research. Higher doses (60%) accelerated lethality (full effect by 16 h) aligns with prior reports of physic nut seed oil extracts causing > 90% mortality in *S. frugiperda* larvae within 72 h via antifeedant and toxic mechanisms (Tchegueni et al. 2023). Alharbi & Alanazi (2024) results showed the repellent, antifeedant, and toxic activity of physic nut against *Rhynchophorus ferrugineus* (Olivier, 1790) (Coleoptera: Curculionidae). Physic nuts outperformed synthetic positive control in speed, supporting it as a viable biopesticide for pests, consistent with its broad efficacy against chewing insects. These findings reinforce integrated pest management strategies emphasizing rapid-acting botanicals over slower chemical standards.

The low performance of Moran® 30 may be associated with reduced susceptibility of larvae to the active ingredient indoxacarb. Resistance to chemical pesticides has been documented among agricultural pests (Venkatesan et al. 2022). Interestingly, both botanical oils showed greater efficacy than the synthetic insecticide Moran® 30 during early exposure periods. This suggests that plant-based pesticides from an ecological perspective offer several advantages: biodegradable, low toxicity to mammals, minimal environmental persistence, reduced resistance development and availability of botanical materials (Ahmed et al. 2022).

Probit analysis showed that neem and physic nut oils are comparably effective biopesticides when evaluated on a concentration basis. Their LC_{50} values, with overlapping 95% confidence intervals, indicate no statistically significant difference in potency and support the interpretation that both treatments exert a similar toxic effect on cutworm larvae. This finding aligns with the broader literature, including Amin et al. (2019) and Dimetry et al (2019), who reported that neem-based formulations remain among the most promising plant derived insecticidal products for managing lepidopteran pests.

Although LC_{50} values indicated equivalent concentration dependent toxicity between neem and physic nut oils, the time mortality analysis revealed a clear distinction in speed of action. Neem oil consistently produced a shorter LT_{50} than physic nut, reflecting a faster onset of mortality and a more rapid biological response. This pattern is particularly relevant for integrated pest management, where quicker suppression reduces feeding damage before larvae reach later instars. Evidence synthesized in the review by Adusei & Azupio (2022) further highlights neem's rapid insecticidal performance against cutworm and other noctuid pests, reinforcing its value as a botanical alternative in vegetable cropping systems.

Figure 1 reveals characteristic dose-response kinetics, with botanical oils demonstrating rapid onset and superior speed over the synthetic positive control, which might be due to azadirachtin and phorbol ester mediated toxicity in cutworm larvae (Alharbi & Alanazi 2024; Almadiy et al. 2025). Overlapping neem and physic nut trajectories validate their equipotent LC_{50} values (~ 9%) and support combined deployment in IPM programs targeting cutworm pests in vegetable crops. These patterns underscore the practical advantages of biopesticides for early-stage control in field applications. Integrating botanical oils into pest management programs, therefore, may improve sustainable pest control and management in cabbage production.

Conclusion

This study demonstrated that seed oils from both neem and physic nut exhibit potent insecticidal activity against cutworm larva as evidenced by mortality rates that increased in a clear dose- and time-dependent manner across concentrations ranging from 15% to 60%

Neem oil achieved a slightly higher and faster efficacy when compared to physic nut with complete mortality of 14-26 h post-exposure.

Both botanical seed oils of neem and physic nut outperformed the synthetic pesticide Moran® 30 during the initial exposure period (<48 h). Consequently, these botanical pesticides of neem and physic nut seed oils are recommended as they are easily accessible, sustainable, and environmentally compatible alternatives for cutworm infestation management in cabbage systems.

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Authors' Contributions

VMS: Conceptualization, supervision, methodology, validation; DUA: Formal analysis, visualization, writing – original draft, writing – review & editing; GY: Investigation, methodology; JSG: Methodology, resources, supervision, validation.

Conflict of Interest Statement

The authors declare that there are no conflicts of interest regarding the publication of this work.

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