Comparative Entomocidal effects of seed and leaf extracts of Azadirachta indica and Jatropha curcas against Fall armyworm (Spodoptera frugiperda) under laboratory conditions

Mayaki Alhaji Cece

mayaki.cece@fedpolybida.edu.ng

Federal Polytechnic https://orcid.org/0009-0004-7047-6597

Israel Kayode Olayemi

Federal University of Technology Minna https://orcid.org/0000-0001-7116-0720

Muhammadu Tajudeen Salaudeen

Federal University of Technology y https://orcid.org/0000-0003-1196-4254

Azubuike Christian UKubuiwe

Federal University of Technology Minna

Ibrahim Maikudi Salihu

African Aviation and Aerospace University Abuja https://orcid.org/0000-0002-2356-9238

Research Article

Keywords: Botanicals, bioactive compounds, larval mortality, larval duration

Posted Date: July 21st, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10362076/v1

Additional Declarations: The authors declare no competing interests.

Comparative Entomocidal effects of Seed and Leaf Extracts of *Azadirachta indica* and *Jatropha curcas* Against Fall Armyworm (*Spodoptera frugiperda*), under Laboratory Conditions

Abstract

Fall Armyworm has been a significant pest control issue since its invasion of Africa in 2016, resulting in significant declines in maize production. This study examine the larvicidal effectiveness of aqueous seed and leaf extracts of *Azadirachta indica* and *Jatropha curcas* to manage the Fall armyworm. The crude extracts obtained were subjected to phytochemical screening and were prepared at different concentrations of 10%, 7.5% and 5% and applied to third-instar larvae. Mortality of Fall armyworm were recorded at 24, 48, 72 and 96 hours after treatment as well as larval duration. The results indicated that, *A. indica* extract recorded the highest concentrations of phenols, flavonoids, tannins, steroids and terpenoids, while *J.. curcas* extract recorded the highest concentrations of alkaloids and saponins. The seed and leaf extracts of *A. indica*, along with the seed extract of *J. curcas*, achieved 100% mortality of Fall armyworm at 96 hours post-treatment. All botanical extracts prolonged the developmental duration of larvae, with the seed extract of *A. indica* recording the highest larval duration of 17.4 days, in comparison to the control, which lasted 12.9 days. All botanical extracts demonstrated significant activity against Fall Armyworm larvae and may provide environmentally friendly alternative to synthetic insecticides.

Keywords; Botanicals, bioactive compounds, larval mortality, larval duration

Introduction

Maize is one of the most important cereal crops cultivated worldwide and serves as a major source of food, feed and industrial raw materials (Erenstein *et al.,* 2022). In Nigeria, maize contribute significantly to food security and household income (Kolapo and Sieber, 2025). However, maize production is threatened by many insects pest, among which the Fall armyworm, is considered one of the most destructive. The young larvae feed within the whorl, while the initial two instars consume foliage gregariously on the undersides of young leaves, leading to a distinctive skeletonizing or windowing effect and thereby diminishing the leaves' photosynthetic area, ultimately resulting in reduced grain yield and destruction of the growing point (Croce *et al*., 2024). The mature caterpillar disrupts pollination and fertilization, damaging the tassel and silks, or it burrows into the maize cob, diminishing harvest quality and increasing susceptibility to secondary diseases (Anjorin *et al*., 2022). The larvae of FAW have the potential to cause maize yield losses ranging from 8.3 - 20.6million metric tonnes per annum in 12 African maize producing countries, valued at US$2.48b - US$6.19b (Prasoona *et al*., 2022). Synthetic pesticides are the predominant approach for managing the FAW in Nigeria and many synthetic pesticides are losing efficacy against the FAW due to pesticide resistance (Li *et al*., 2025). Additionally, insecticides are prohibitively expensive and contribute to environmental pollution, adversely affecting beneficial flora and fauna in terrestrial and aquatic habitats. Botanical extracts such as *Azadirachta indica* and *Jatropha curcas* have been suggested as viable alternatives to synthetic insecticides for FAW control, being environmentally benign, cost-effective, typically target-specific, and biodegradable (Kumar *et al*., 2025) which contain bioactive compounds with insecticidal, and growth- regulating properties. Despite numerous reports on the pesticidal properties of *A. indica* and *J. curcas*, comparative evaluation of different plant species and plant parts against Fall armyworm remains limited. Therefore, this study aimed to evaluate the efficacy of *A. indica* and *J. curcas* crude extracts against FAW larval under laboratory conditions and their potential for incorporation into integrated pest management programs.

Materials and Methods

Study Location

The experiment was conducted in the Biology Laboratory of the Department of Animal Biology, Federal University of Technology Minna, Nigeria under laboratory conditions of 27±2 °C, 70±5% relative humidity and a 12:12 h light-dark photoperiod.

Collection and Authentication of Plant Specimens

Seeds and leaves from *Jatropha curcas* (Physic nut) and *Azadirachta indica* (Neem) were gathered from the Biological Garden of Federal Polytechnic Bida in Niger State Nigeria and brought to the laboratory of the Department of Animal Biology at Federal University of Technology, Minna, Nigeria. A Botanist from the Department of Plant Biology at Federal University of Technology Minna authenticate the plant specimens. A voucher specimen of the plant material was submitted to the Herbarium of the Department of Animal Biology at Federal University of Technology Minna for referencing. The various parts of the plants were chopped into smaller pieces, rinsed with distilled water, and air-dried at a temperature of 27±2 °C for two weeks until they achieved a steady weight (Boica Junior *et al.,* 2020).

Preparation and Extraction of Plant Materials

The seeds and leaves of *Jatropha curcas* (Physic nut) and *Azadirachta indica* (Neem) were ground into a fine powder using a Panasonic Blender MX134 and subsequently sieved through a 0.1 mm mesh to standardize the plant particles, which were then stored in labeled containers for extraction. The methods outlined by Phambala *et al*. (2020) was implemented with few adjustments. One hundred grams of each plant powder was immersed in 1000 ml of distilled water for 72 h. The mixture was intermittently stirred with a glass rod at six-hour intervals to ensure uniform solvent distribution. Subsequently, it was filtered through a clean muslin cloth and then through Whatman number 1 filter paper to obtained the filtrate (Padial *et al*., 2023). The filtrate was treated to a rotating vacuum evaporator at 50 °C (Lima *et al*., 2023) until all solvent was evaporated to yield the crude extract, which was subsequently reconstituted to prepared 10,0 7.5 and 5.0 % (w/v) concentrations of the crude aqueous extracts after preliminary test.

Quantitative Phytochemical Screening of Plant Extracts

The analysis included the determination of total phenolic content, total tannin content, total alkaloid content, total flavonoid content and terpenoids content using standardized protocols reported by Selvakumar *et al.* (2019)

Collection and Rearing of Fall Armyworm (FAW) larvae

Fall Armyworm larvae were gathered from untreated maize fields during their vegetative phase. The collection was accomplished using entomological brushes, and the larvae were brought to the laboratory for breeding with maize leaves in a plastic container placed in a growth chamber maintained at a temperature of 27±2 °C, 75±5 % relative humidity, and a 12:12 h light-dark photoperiod (Prasoona *et al*., 2022) until the larvae developed into pupae. The pupae were collected and moved to a petri dish lined with damp filter paper to prevent drying and then placed into cages for adult emergence. When the adults (both male and female) emerged, they were provided with a cotton wool soaked in honey, which was placed in oviposition cages (Phambala *et al*., 2020). The oviposition cages were draped with black cloth and secured with a rubber band to create the dark conditions necessary for mating and egg-laying by the females (Prasoona *et al*., 2022). Subsequently, fresh maize leaves were added to the rearing cages for egg-laying (Kumar *et al*., 2019). The eggs that were deposited on fresh leaves or filter paper were collected daily (Phambala *et al*., 2020). Subsequently, batches of eggs were permitted to hatched into the larval stage and were reared into third- instar larvae stage prior to being utilized for bioassays..

Laboratory Bioassay

Fresh maize leaves, aged 15-30 days, were cut into 4 cm diameter discs and bathed in 10, 7.5 and 5.0 % (w/v) concentrations of each extract, while the control larval leaves were submerged in distilled water for three minutes and subsequently air-dried on filter paper for one hour (Phambala *et al*., 2020). The FAW larvae were deprived of food for six hours to stimulate a heightened feeding rate prior to their placement in the plastic containers. Maize leaves were changed daily, and feces were removed. Thirty (30) third instar larvae of FAW where used for each treatment in which each plastic container housed five pairs of third instar larvae of FAW to avert cannibalism (Altaf *et al.,* 2022). All plastic containers were enveloped in muslin cloth, secured with a lid that featured perforations to prevent the escape of FAW larvae while permitting ventilation. All treatments, including the control and Emamectin benzoate 5% as the standard control, were reproduced three times and organized in a completely randomized design (CRD). The mortality of the FAW larvae was documented at 24, 48, 72, and 96 h post-treatment (HPT). A larval was deemed deceased when no portion of its body exhibits movement upon gentle contact with a brush (Sisay *et al*., 2019). The percentage mortality of Fall Armyworm was determined using the formula outlined by Sakadzo *et al*. (2020) $\%\ \text{Larval Mortality} = \frac{Numberofdeadlarval}{Totalnumberoflarvae} \times 100$

The larvae instars were exposed to sub-lethal concentration of each of the crude extract to evaluate their effect on the duration of development of the six larval instars of FAW. Observations were conducted at 24 hours interval until each instar progressed to the subsequent stage up to pupal stage

Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA). Treatment means were separated using Tukey's HSD at 5% probability level. Probit analysis was used to estimate LC_{50} and LC_{90} values..

Results

Quantitative Phytochemical Composition of Aqueous Seed and Leaf Extract of *Azadirachta indica* and *Jatropha curcas*

The quantitative phytochemical composition of aqueous seed and leaf extract of *A. indica* and *J. curcas* are presented in Table 1. There were significant ($p < 0.05$) differences in concentrations of bioactive compounds found among the botanical extracts. The concentrations of phenol were found between the ranged of 355.12 and 620.03 mg/100g. Leaf extract of *Azadirachta indica* (LEAI) recorded the highest concentration of phenol (620.03 mg/100g), followed by Seed extract of *A. indica* (SEAI) (544.23 mg/100g), followed by Leaf extract of *J. curcas* (LEJC) (377.75 mg/100g) and the least concentration was recorded in seed extract of *J. curcas* (SEJC) (355.12 mg/100g), likewise, the concentration of flavonoids were found between the ranged of 40.83 and 78.70 mg/100g. The highest concentrations of flavonoids was obtained in LEAI (78.70 mg/100g) while 65.97mg/100g, 48.75mg/100g and 40.83m/100g were recorded in SEAI, LEJC and SEJC respectively. The LEAI (134.94 mg/100g) recorded the highest contents of tannins while 120.72mg/100g, 83.77mg/100g and 70.09mg/100g were obtained in SEAI, LEJC and SEJC respectively. The concentration of saponins in botanical extracts ranged between 110.05mg/100g and 136.35mg/100g with LEJC recorded the highest concentration (136.35mg/100g) while SEAI recorded the lowest concentration (110.05mg/100g). The concentrations of terpenoids ranged between 41.20mg/100g and 79.20mg/100g while steroids ranged between 48.42mg/100g and 78.25mg/100g

Table 1: Quantitative Phytochemical Analysis of Selected Botanical Extracts

Phytochemical	**Concentration SEAI**	**of botanicals LEJC**	**(mg/100g) LEAI**	**SEJC**
Phenol	544.23±1.12^{c*}	377.75±0.81^{b}	620.03±0.41^{d}	355.12±1.12^{a}
Flavonoids	65.97±0.60^{c}	48.75±0.61^{b}	78.70±0.37^{d}	40.83±0.56^{a}
Tannins	120.72±0.86^{c}	83.77±0.94^{b}	134.94±0.77^{d}	70.09±0.77^{a}
Alkaloids	20.74±0.78^{a}	33.75±0.81b^{c}	29.54±1.11^{b}	36.88±0.48^{c}
Saponins	110.05±0.87^{a}	136.35±1.22^{c}	121.75±0.60^{b}	129.77±0.64^{bc}
Terpenoids	62.68±0.64^{c}	41.20±0.14^{a}	79.20±0.14^{d}	53.24±0.01^{b}
Steriods	72.37±0.06^{c}	62.25±0.07^{b}	78.25±0.21^{d}	48.42±0.14^{a}

* Values followed by the same superscript alphabets in a row are not significantly different at P > 0.05. Values are represented in mean ± standard error of three replicates
keywords: SEAI = Seed extract of *A. indica* SEJC = Seed extract of *J. Curcas*;
LEAI = Leaf extract of *A. indica* LEJC = Leaf extract of *J. Curcas*;

Percentage Mortality of Fall Armyworm Larvae after Exposure to Different Botanical Extracts at 10% Concentration under Laboratory Conditions

Percentage mortality of FAW larvae after exposure to different botanical extracts at 10% concentration in the laboratory are detailed in figure 1. There was gradual increased in mortality of FAW among the botanical extracts. The results indicated that, there were no significant ($p > 0.05$) differences among the mortality of FAW recorded in SEAI. SEJC and LEAI. The % mortality of FAW ranged from 20% to 56.7% among all the botanical extracts after 24 h treatment while EMMB recorded 96.7% mortality of FAW and untreated control recorded 0.0% mortality of FAW larvae. At 48 h post treatment, there were significant ($P < 0.05$) differences between the mortality of FAW recorded in SEAI and the three botanical extracts (SEJC, LEAI and LEJC). No significant ($p > 0.05$) different between LEAI and SEJC was recorded. Seed extract of *A. indica* recorded the highest mortality (73.3%) of FAW larvae at 10% concentration while the LEJC recorded the lowest mortality (36.7%) of FAW larvae and EMMB recorded 100% mortality of FAW while untreated control recorded 0.0% mortality. There were significant ($p< 0.05$) differences in % mortality of FAW between SEAI and LEAI, SEJC and LEJC after 72h treatment which recorded 93.3%, 76.7%, 63.3% and 46.7% mortality respectively, while EMMB recorded 100% mortality of FAW and untreated control recorded 3.33% mortality of FAW larvae. At 96 h post treatment, there was no significant ($p > 0.05$) differences of mortality of FAW recorded among SEAI, LEAI, SEJC and EMMB in which each recorded 100% mortality of FAW larvae while LEJC recorded 50% mortality of FAW larvae comparable to untreated control that recorded 3.33% mortality of FAW.

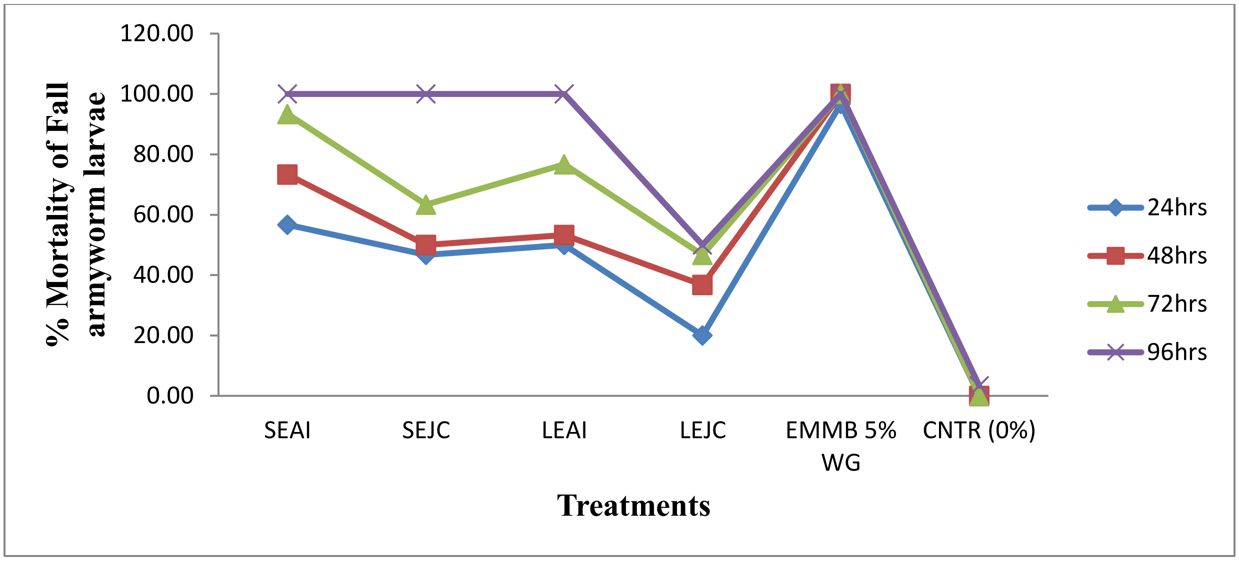

Fig. 1: Percentage Mortality of Fall Armyworm Larvae after Exposure to Different Botanical Extracts at 10 % Concentration under Laboratory conditions.

key: SEAI = Seed extract of *A. indica*; SEJC = Seed extract of *J. Curcas*; LEAI = Leaf extract of *A. indica*; LEJC = Leaf extract of *J. Curcas*; EMMB= Emamectrin benzoate, CNTR = Untreated Control

Percentage Mortality of Fall Armyworm Larvae after Exposure to Different Botanical Extracts at 7.5% Concentration under Laboratory Conditions

Figure 2 showed the percentage mortality of FAW larvae after exposure to different botanical extracts at 7.5% concentration in the laboratory. There were no significant ($p > 0.05$) differences between the value of mortality of FAW obtained in SEAI, SEJC and LEAI. The results revealed that, percentage mortality of FAW ranged between 16.7% to 46.7% at 24 h after treatment while EMMB and control recorded 96.7% and 0.0% mortality respectively. At 48 h after treatment, there was no significant ($p > 0.05$) different between SEAI and LEAI but significant ($p < 0.05$) different was observed between SEJC and LEJC. At 72 h post treatment, there were significant ($p < 0.05$) differences among all the botanical extracts. The mean percentage mortality of FAW ranged between 40% to 70% and the highest mortality among the botanical extracts was recorded in SEAI and LEAI reaching 70% and 66.7% respectively while SEJC and LEJC recorded 56.7% and 40% mortality respectively. The botanical extracts also demonstrated significant ($p < 0.05$) different at 96 h after treatment, although no significant different was recorded between LEAI and SEJC. The mortality of FAW ranged between 46.7% to 80%, with highest mortality of 80% was recorded in SEAI, followed by 73.3% in LEAI, SEJC recorded 66.7% and lowest mortality (46.7%) of FAW was recorded in LEJC while EMMB recorded 100% mortality of FAW larvae and untreated control recorded 3.33%

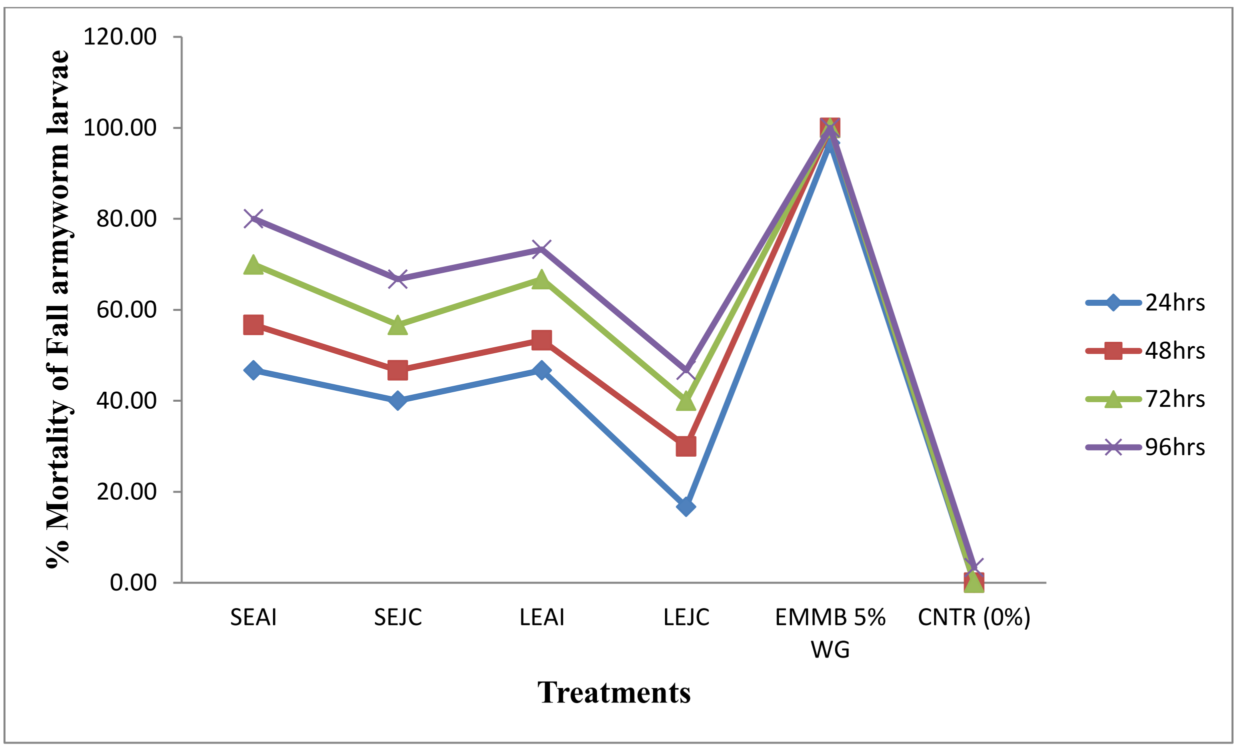

Fig. 2: Percentage Mortality of Fall Armyworm Larvae after Exposure to Different Botanical Extracts at 7.5 % Concentration under Laboratory Conditions.

key: SEAI = Seed extract of *A. indica*; SEJC = Seed extract of *J. Curcas*; LEAI = Leaf extract of *A. indica*; LEJC = Leaf extract of *J. Curcas*; EMMB= Emamectrin benzoate, CNTR = Untreated Control

Percentage Mortality of Fall Armyworm Larvae after Exposure to Different Botanical Extracts at 5% Concentration under Laboratory Conditions

Percentage mortality of FAW larvae after exposure to different botanical extracts at 5% concentration in the laboratory are presented in figure 3. The results indicated that, mean % mortality of FAW ranged between 13.3% to 43.3% among the botanical extracts at 24 h post treatment while % mortality ranged between 26.7% to 50% at 48hrs post treatment. There were no significant ($p > 0.05$) differences among the three botanical extracts (SEAI, SEJC and LEAI). At 72 h post treatment, there was no significant ($p > 0.05$) different between SEAI and LEAI as well as SEJC and LEJC. The % mortality of FAW ranged between 33.3% to 56.7% with highest % mortality (56.7%) was recorded in LEAI, followed by SEAI (53.3%), followed by SEJC (46.7%) and LEJC recorded the lowest % mortality (33.3%) of FAW larvae while EMMB recorded 100% mortality and untreated control recorded 0.0% mortality of FAW larvae. At 96hrs post treatment, there was no significant ($p > 0.05$) different between SEAI and LEAI. The mean % mortality of FAW among the botanical extracts, ranged between 43.3% to 60% with highest % mortality (60%) recorded in SEAI, followed by LEAI (56.7%) and 50% mortality was recorded in SEJC while 43.3% was recorded in LEJC and 3.33% mortality of FAW was recorded in untreated control test while EMMB recorded 100%. Mortality.

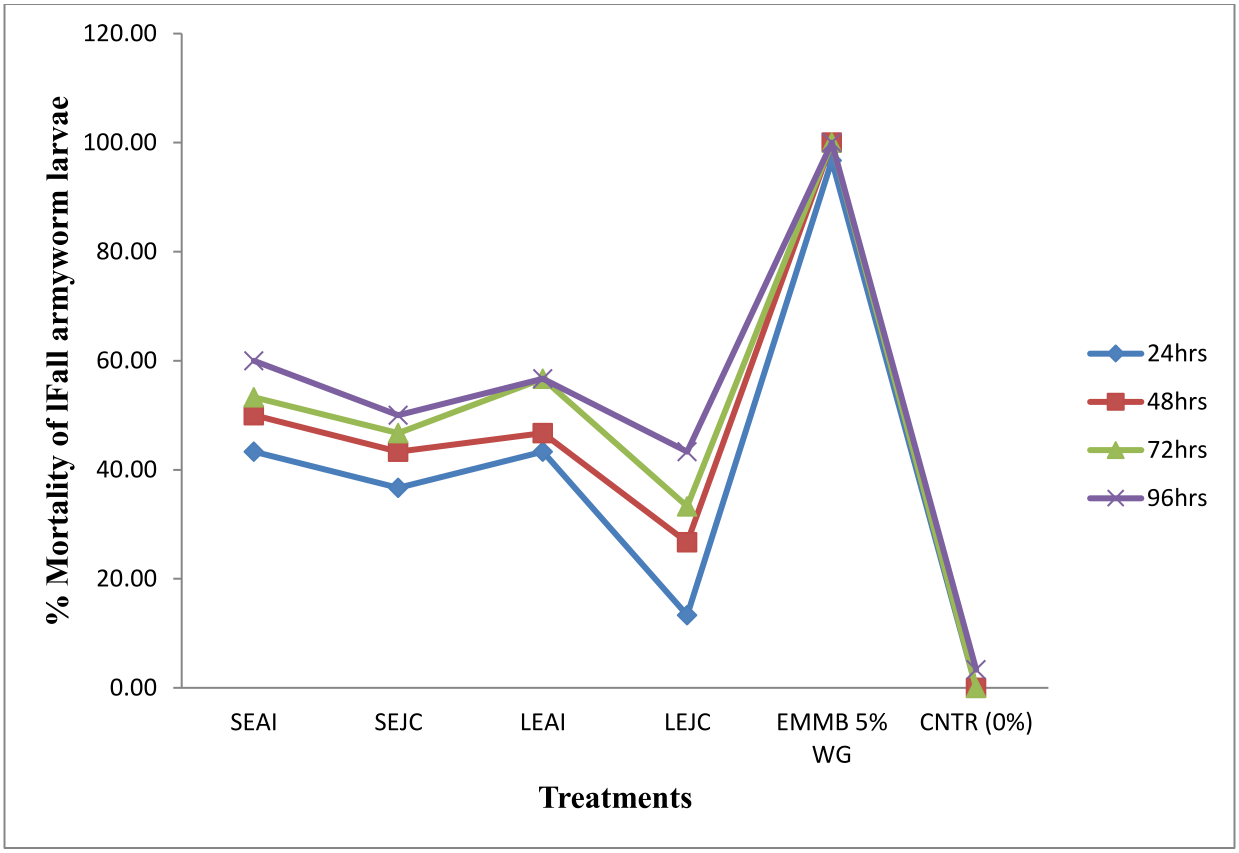

Fig. 3: Percentage mortality of Fall armyworm larvae after exposure to different botanical extracts at 5 % concentration under laboratory conditios.

key: SEAI = Seed extract of *A. indica*; SEJC = Seed extract of *J. Curcas*; LEAI = Leaf extract of *A. indica*; LEJC = Leaf extract of *J. Curcas*; EMMB= Emamectrin benzoate, CNTR = Untreated Control

Lethal concentrations

LC_{50} and LC_{90} values at 24 h and 48 h are presented in Table 2. After 24 h, SEAI was the most toxic extract, with an LC_{50} of 7.95% and LC_{90} of 21.59% ($R^2 = 0.968$). SEJC, LEAI, and LEJC recorded LC_{50} values of 11.18%, 9.38%, and 32.50%, respectively. After 48 h, LC_{50} values decreased across all treatments: SEAI (5.08%), SEJC (9.38%), LEAI (7.14%), and LEJC (18.27%), indicating progressive insecticidal activity over time.

Table 2: Median (LC_{50}) and upper (LC_{90}) lethal concentration of the aqueous extracts of seed and leaf of *Azadirachta indica* and *Jatropha curcas* against Fall armyworm

	24hours				48hours			
Treatment	LC_{50}	LC_{90}	R2	regression equation	LC_{50}(%)	LC_{90}	R2	Regression equa.
SEAI	7.95	21.59	0.968	2.9333×+26.667	5.08	14.45	0.966	4.2667×+28.333
SEJC	11.18	26.97	0.963	2.5333×+21.667	9.38	28.13	0.914	2.1333×+30.00
LEAI	9.38	28.13	0.914	2.1333×+30.000	7.14	28.57	0.891	1.8667×+36.667
LEJC	32.5	62.5	1.000	1.333×+6.667	18.27	41.35	0.966	1.73333×+18.333

Effect of Sub-lethal Concentrations on Larvae instars Duration of Fall Armyworm

Table 3 showed the effect of sub-lethal concentration on the developmental period of larval instars of FAW. The sub-lethal concentration of all botanical extracts extended the duration of larval instars. The overall larval duration of FAW was considerably lengthened ($p < 0.05$) on maize leaves treated with SEAI (17.4 days), followed by those reared in treated with LEAI (15.7 days), SEJC (15.4 days), and LEJC (14.7 days) comparable to untreated control (12.9 days). No significant variations ($p > 0.05$) were observed in the duration of the first larval instar (2.7 days) among the sub-lethal concentrations of all botanical extracts, while a significant difference was noted when compared to the untreated control (2.3 days). The duration of three days (3.0 days) was seen for the second larval instar of FAW raised on maize leaves treated with SEAI and LEAI, whereas a duration of 2.7 days was noted for SEJC and LEJC. The untreated control exhibited a larval duration of 2.3 days during second larvae instar. The fourth larval instar exhibited a duration of 2.7 days when grown on maize leaves treated with SEAI, while a length of 2.3 days was seen for larvae on maize leaves treated with SEJC, LEAI, and LEJC while untreated control recorded a larval duration of 2.0 days. The SEAI documented a duration of 3.0

days for the fifth larval instar of FAW, whereas a duration of 2.7 days was noted for larvae in LEAI, SEJC, and LEJC. The duration of 3.0 days was seen for the sixth larval instar grown on maize leaves treated with SEAI, whereas a duration of 2.7 days was noted for SEJC and LEAI treatments, and the untreated control exhibited a duration of 2.0 days.

Table 3: Effect of Sub-lethal Concentrations of Different Botanical Extracts on Larval instars Duration of Development of FAW under Laboratory Condition

	Mean duration of larval instars (days) Mean ± SE				
Larval instar	SEAI (1.415%)	SEJC (2.161%)	LEAI (1.072%)	LEJC (18.140%)	CNTR (0.0%)
1st	2.7±0.58^{b}	2.7±0.58^{b}	2.7±0.58^{b}	2.7±0.58^{b}	2.3±0.58^{a}
2nd	3.0±0.00^{c}	2.7±0.58^{b}	3.0±0.00^{c}	2.7±0.58^{b}	2.3±0.58^{a}
3rd	3.0±0.00^{c}	2.3±0.58^{b}	2.3±0.58^{b}	2.0±0.00^{a}	2.0±0.00^{a}
4th	2.7±0.58^{c}	2.3±0.58^{b}	2.3±0.58^{b}	2.3±0.58^{b}	2.0±0.00^{a}
5th	3.0±0.00^{c}	2.7±0.58^{b}	2.7±0.58^{b}	2.7±0.58^{b}	2.3±0.58^{a}
6th	3.0±0.00^{d}	2.7±0.58^{c}	2.7±0.58^{c}	2.3±0.58^{b}	2.0±0.00^{a}
Total larval duration	17.4±1.16^{d}	15.4±3.00^{c}	15.7±2.90^{c}	14.7±2.90^{b}	12.9±1.74^{a}

* Values followed by the same superscript alphabets in a row are not significantly different at P > 0.05. Values are represented in mean ± standard error of their replicates

key: SEAI = Seed extract of *A. indica*; SEJC = Seed extract of *J. Curcas*; LEAI = Leaf extract of *A. indica*; LEJC = Leaf extract of *J. Curcas*; CNTR = Untreated Control

Discussion

The results demonstrate that, there were variation in concentrations of bioactive compounds in different botanical extracts. The varying concentrations of bioactive compounds in different botanical extracts suggest that, exploring other options of extraction methods could yield more bioactive compounds for insecticidal use and would lead to their development of standardized extracts for consistent in fields application (Ujah *et al*., 2021). The concentrations of phenol in the extract of all botanicals were significantly higher compared to values reported by other authors.

Botanical extracts (*A. indica* and *J. curcas*) utilized in this study demonstrate considerable potential as natural substitutes for synthetic owing to their bioactive compounds with insecticidal efficacy (Ali *et al*., 2025). The selection of these botanicals was based on their well documented insecticidal activities against FAW, availability and low environmental impact (Filonemo *et al*., 2020; Degaga and Degaga, 2024). In this study, botanical extracts has showed different level of efficacy against third larvae instar of FAW. The extracts of SEAI, LEAI and SEJC consistently resulted in high larvae mortality which is similar with those of Sisay *et al*. (2019) who reported high larvae mortality of FAW using the seeds extract of *A. indica* and *J. curcas*. The SEAI, LEAI and SEJC recorded the most effective against FAW in this study, causing mortality rates of FAW between 63.3% to 100%. These findings, is similar with previous studies reporting similar mortality rates on FAW (Degaga and Degaga, 2024). Idrees *et al*. (2021) observed elevated neonate mortality of FAW with *Beauveria bassiana*, corroborating the results of our investigation. The efficacy of botanicals extracts against FAW larvae exhibited variability in this investigation Seventy-two hours post-treatment application, the seed and leaf of *A. indica* extract demonstrates considerable larvicidal efficacy against FAW larvae, with mortality rates differing at various time intervals, indicating varied rates of action. Conversely, Degaga and Degaga (2024) revealed that, there was no significant difference in the efficacy of neem seed and leaf extracts against FAW. Degaga and Degaga (2024) demonstrated that, neem leaf extract resulted in 81.7% death of FAW at 72hrs after treatment application, significantly exceeding the mortality rate of FAW recorded in our study. The seeds and leaves extract of *A. indica* showed significant larvicidal effects on FAW larvae, with differences in mortality rates appearing at different time points, suggesting varying speeds of action. On the contrary, Degaga and Degaga (2024) demonstrated that, there was no significant differences between the effectiveness of seeds and leaves extract of neem against FAW. Degaga and Degaga (2024) reported that, Neem leaf extract caused 81.7% mortality of FAW at 72hrs after treatment, which is considerably higher than the mortality of FAW observed in this study. The discrepancies may be ascribed to the method of extraction. The extract of A. indica leaf exhibited a mortality rate of 76.7% in FAW larvae at 72 h post-treatment, surpassing the figure documented by Phambala *et al*. (2020). Also in contrast, Saleem *et al*. (2024) reported 64% mortality rate of FAW at 72 h post-treatment when fed on maize leaves treated with LEAI. The discrepancies may be ascribed to the solvent employed for the extraction of plant components or the concentration of the formed extract. The efficacy of the therapy on the seeds and leaves of *A. indica* regarding FAW may stem from the capacity of Azadirachtin to suffocate the FAW, resulting in mortality, alongside its several modes of action, functioning as a repellant, antifeedant, insect growth regulator, and attractant (Mukanga *et al*., 2022). There was a substantial difference in the efficacy of SEAI and SEJC after 72 h of treatment. In this study, SEAI shown superior efficacy compared to SEJC. Conversely, Ahmed (2023) observed that there was no significant difference in the efficiency of the seed extract of *J. curcas* and *A. indica* at 72 h post-treatment application on FAW larvae. The mismatch, may be ascribed to variations in concentration, temperature, or relative humidity. At 96 h post-treatment, SEAI, LEAI, and SEJC achieved 100% mortality of FAW comparable to the efficacy of EMMB. This aligns with prior research (Degaga and Degaga, 2024). The aqueous extract of *J. curcas* leaves in this investigation exhibited limited insecticidal activity against FAW at 24 to 72 h post-treatment, which may be ascribed to the concentration levels utilized. The high efficacy of *A. indica* and *J. curcas* can be attributed to their phytochemical contents.

The high mortality of FAW recorded in *A. indica* may be attributed to high concentrations of phenol and tannins. Phenolic compounds have strong antioxidant properties, which can disrupt the metabolism of insect. Wang *et al.* (2018) demonstrates the relationship between phenolic contents and antioxidant activity in various plant species have shown that, higher phenolic content are linked to increased antioxidant activity. Emamectin benzoate 5% utilized as a reference in this study, shown substantial efficacy against FAW, with mortality rates between 96.7% and 100%. These findings is similar with those of Ali *et al*. (2025), who reported a mortality rate of 53.5% to 100% for FAW. The control experiment demonstrated 0.0% mortality of FAW at 24, 48, and 72 h post-treatment, confirming that the observed mortality in the treated trial was exclusively attributable to the toxic effects of the botanical extracts. All botanical extracts exhibited notable efficacy in managing FAW, with mortality rates demonstrating a clear dependence on both concentration and exposure duration; higher extract concentrations and prolonged exposure times resulted in significantly increased larval mortality. The LC_{50} of 7.95% for SEAI indicates it is the most potent extract. This value exceeds the 263.02 ppm reported for shallot leaf (*Allium ascalonicum*) extract against Fall armyworm (Putri and Aini, 2021), but is considerably lower than the 1 479 ppm recorded for *Annona mukosa* seed extract against *Helicoverpa armigera* (Souza *et al.,* 2017). These differences likely reflect variations in extraction solvent polarity, plant species, and target insect susceptibility.

All botanical extracts extended the duration of the FAW larvae instar and this may be due to the high concentrations of bioactive compounds in botanicals such as Phenol, tannins, saponin and terpenoids which can alter normal growth. Pavana *et al.* (2023) reported that, the lower growth rate is due to the principal compounds present in the botanicals, which interferes with the growth by disrupting the normal functions of the endocrine system and decreased the efficiency of converting food into biomass in turn reducing the growth rate. The results of this study indicate that the larval instar development of FAW can greatly differ according on plant type. The total larval duration (17.4 days) recorded in the SEAI significantly differs from other botanicals and the untreated control, likely due to the presence of *Azadirachtin* in the seed extract of *A. indica*, which may function as a moulting inhibitor, hindering the larvae's capacity to shed their exoskeleton and impeding their progression to subsequent developmental stages. Chaudhary *et al.* (2017) found that neem extract disrupts the hormonal equilibrium essential for effective moulting, particularly by suppressing ecdysone activity, hence prolonging the larval phases and preventing their development into adulthood. The results of this study is similar with those of Bezerra *et al*. (2019), who reported a larval duration of 18 days when FAW larvae were reared on maize leaves treated with *Machaerium opacum* leaf extract. However, they contrast with the findings of Martinez *et al*. (2017), which indicated a larval duration of 19.38 days for FAW larvae reared on maize plants treated with *Argemone ochroleuca*. The discrepancies may stem from changes in plant species utilized for FAW management, the solvents employed, or concentration of the extracts. Zavala-Sánchez *et al.* (2019) reported that, the exposure of larval of FAW to chloroform extract of the leaves of *Senna crotalarioides* extends the duration of the larval stage of FAW to 23.7 days.

Conclusion

This study evaluates the FAW larvicidal efficacy and larval growth regulatory potentials of seed and leaf extract of *A. indica* and *J. curcas.* The results of the phytochemical constituents of *A. indica* and *J. curcas* indicate that, the botanicals contains important bioactive compounds e.g tannins, phenol, saponins and flavonoids that may be widely used as alternative for synthetic insecticides in integrated pest management programs especially for smallholder farmers. The results of larvicidal bioassay activities of the seed and leaf extract of *A. indica* and *J. curcas* caused 100% mortality of FAW at 10% concentration after 96 hours treatment and delayed larval duration. Botanical extracts offer a promising eco-friendly approach for managing Fall armyworm infestations and reducing dependence on synthetic pesticides, additional research is required to corroborate the findings of this study under field conditions.

Acknowledgements

We want to appreciate the management of the Department of Animal Biology, Federal University of Technology, Minna, Nigeria for providing enable environment where the experiment was conducted in Biology Laboratory.

Authors contributions.

Cece, M. A: Carried out experiment, writing the first draft, Olayemi, I. K: Conceptualized the idea, methodology, validation, Salaudeen, M. T: Supervision, writing original draft, writing review, Ukubuiwe, A. C: writing review and editing, Salihu, I. M: Conduct data analysis and revised second draft.

Consent for publication

All the authors agreed that the submitted work has not been published previously, that the work is not under consideration for publication elsewhere and that all authors agreed to the publication of this work

Conflict of interest

All the authors has agreed that, there is no conflict of interest,

Funding

No financial assistance was received from individual or organization

Data availability and materials

All data supporting the findings of this study are available within the paper

Animal ethic declaration: Not applicable

References

Ahmed, S. (2023). Screening of Management options and efficacy evaluations against Fall Armyworm (J.E.Smith) (Lepidoptera: Noctuidae) on maize in Assosa, Ethiopia. *Journal of Entomology and Ornithology,* 1(1), 000101.

Ali, M. A., Abd‑Elgalil, D. M. S.. Bakry, M. M. S. & Mohamed, G. S. (2025).Evaluation of the.potential toxicity of plant extracts, pathogenic fungi, and chemical pesticides for the.management of *Spodoptera frugiperda. Journal of Plant Diseases and Protection* 132,.103.

Altaf, N., Arshad, M., Majeed, M.Z., Ullah, M. I., Latif, H., Zeeshan, M., Yousuf, G. & .Afzal, M. (2022). Comparative effectiveness of Chlorantraniliprole and neem leaf extract against Fall Armyworm, *Spodoptera frugiperda* (J.E.Smith) (Lepidoptera:.Noctuidae). *Sarbad Journal of Agriculture,* 38(3), 833-840.

Anjorin, F. B., Odeyemi, O. O., Akinbode, O. A. & Kareem, K. T. (2022). Fall Armyworm (S*podoptera frugiperda*) (J. E. Smith) (Lepidoptera:Noctuidae) infestation: maize yield depression and physiologicalbasis of tolerance. *Journal of Plant Protection Research,*.62..(1), 12–21

Bezerra, E. F., Santos, R. G., Menezes, S. C. A., Almeida, S. C. A., Jesus, G. F., Rocha, C. E. & Araujo, S. M. (2019). Toxicity of *Machaerium opacum* (Fabaceae) leaf extracts against Fall Armyworm (*Spodoptera frugiperda* (JE Smith) (Lepidoptera Noctuidae). *Journal Agricultural Science,*11, 292- 301.

Boica Junior, A. L., Rodrigues, N. E. L., Janini, J. C. , Bottega, D. B. , Sousa, V. Q. & Silva, A. G. D. (2020). Association of peanut cultivars and aqueous neem extract in the feeding and development of *Spodoptera frugiperda* (J. E. Smith). *Entomo Brasilis,* 13, e909

Chaudhary, S., Kanwar, R. K., Sehgal, A., Cahill, D. M., Barrow, C. J., Sehgal, R., & Kanwar, J..R. (2017). Progress on *Azadirachta indica* based biopesticides in replacing synthetic .toxic pesticides. *Frontiers in Plant Science,* 8, 226969.

Croce, R., Carmo-Silva, E., Cho, Y. B., Ermakova, M., Harbinson, J., Lawson, T. & Zhu, X. G. (2024). Perspectives on improving photosynthesis to increase crop yield. *The plant cell*, 36(10), 3944-3973.

Dagaga, A. H. & Degaga, E. G. (2024). Natural enemies of the Fall Armyworm and comparing Neem aqueous extracts with its larvae, Gurage Zone, Central Ethopia. *Heliyon,* 10 (11),e32083.

Erenstein, O., Jaleta, M., Sonder, Sonder, K., Mottaleb, K. A & Prasanna, B. M. (2-22). Global.maize production, consumption and trade. Trends and R&D implication. *Food Security,*14, 1295-1319.

Filomeno, C. A., Barbosa, L., Teixeira, R., Pinheiro, A. L, Farias, E. S., Ferreira, J. S. & Picanco, M. (2020). Chemical diversity of essential oils of Myrtaceae species and their insecticidal .activity against *Rhyzopertha dominica*. *Crop Protection,* 137, 105309.

Idrees, A., Qadir, Z. A., Akutse, K. S., Afzal, A., Hussain, M., Islam, W., & Li, J. (2021). .Effectiveness of entomopathogenic fungi on immature stages and feeding performance of Fall Armyworm, *Spodoptera frugiperda* (Lepidoptera:Noctuidae) larvae. *Insects*, 12(11), 1044

Kolapo, A. & Sieber, S. (2025). *From vulnerability: Climate-smart agriculture as drivers of productivity and food securityin Nigerian maize-based farming households,* .Environmental Challenges, 20, 101268.

Kumar, R., Kaur, R., Ranout, A. S., & Nadda, G. (2025). A Review on Novel Formulations and Delivery Systems of Botanical Insecticides for Enhanced Efficacy: *Neotropical Entomology*, 54(1), 81

Li, X., Wang, S., Zhu, L., Zhang, P., Qi, H., Zhang, K. & Liu, L. (2025). Leaf hydraulic decline coordinates stomatal and photosynthetic limitations through anatomical adjustments under drought stress in cotton. *Frontiers in Plant Science*, 16, 1622308.

Lima, A. F., Ribeiro, L. P., Lira, S. P., Carvalho, G. A. & Vendramim, J. D. (2023). Growth Inhibitory Activities and Feeding Deterrence of Solanaceae-Based Derivatives on Fall Armyworm. *Agriculture,* 13, 420.

Martinez, A.M., Aguado-Pedraza, A.J., Vinuela, E., Rodríguez- Enríquez, C.L., Lobit, P., Ómez, B. & Pineda, S. (2017). Effects of ethanolic extracts of *Argemone ochroleuca* (Papaveraceae) on the food consumption and development of *Spodoptera frugiperda* (Lepidoptera: Noctuidae). *Florida Entomologist,* 100, 339–345.

Mukanga, M., Machuku, O., Chipabika, G., Matimelo, M., Mumba, K., Chipabika, G., Mabote, N. D., Simwinga, V., Nthenga, I., Lupulula, M., Tembo, S. M. & Lwinya, K.(2022). Bio-efficacy of Crude Aqueous Leaf Extracts against the Fall Armyworm (*Spodoptera frugiperda*) and Maize Ear Rots in Zambia. *Advance in Biological Research*, 3 (1), 38-49.

Padial, I. M. P. M., Souza, S. A. D., Malaquias, J. B.; Cardoso, C. A. L.; Pachú, J. K. D. S.; Fioratti, C. A. G. & Mussury, R. M. (2023). Leaf Extracts of *Miconia albicans* (Sw.) Triana (Melastomataceae) Prevent the Feeding and Oviposition of *Plutella xylostella* (Linnaeus, 1758) (Lepidoptera: Plutellidae). *Agronomy* 13, 890.

Pavana, J. K., Sharanabasappa, S. D., Mallikarjuna , H. B., Kalleshwaraswamy, C. M., Basavaraj, N. T. & Mota-Sanche, D. (2023). Sublethal effects of botanicals on the growth and development of Fall armyworm, *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae). *Current Science.* 125(1), 52-58

Phambala, K.,Tembo,Y., Kabambe, V.H., Stevenson, P. C. & Belmain, S. R. (2020). Bioactivity.of Common Pesticidal Plants on Fall Armyworm Larvae (*Spodoptera frugiperda*), *Plants*, 9 (1), 112.

Prasoona, U. S., Kolhe, A.V., Tathode, V. R. & Tidke, V. N. (2022). Antifeedant activity of some botanicals against *Spodoptera frugiperda* (JE Smith) under laboratory condition. *The Pharma Innovation Journal,* 11 (1), 101-104.

Putri, D. A. & Aini, P. N. (2021). Ethanolic extract of shallot leaves (*Allium ascalonicum* L.) as botanical pesticide to control Fall armyworm (*Spodoptera frugiperda). J. Biotechnol. Nat. Sci*. 2 1(2): 100–104.

Sakadzo, N., Makaza, K. & Chikata, L. (2020). Biopesticidal Properties of Aqueous Crude Extracts of Tobacco (*Nicotiana Tabacum* L.) Against Fall Armyworm (*Spodoptera Frugiperda* J. E Smith) on Maize Foliage (*Zea mays*) Diets. *Agricultural Science*, 2 (1), 47- 55.

Saleem, U, Asrar, M., Jabeen, F., Hussain, S. M. & Hussaini, D. (2024). Determination of insecticidal potentials of selected plant extracts against Fall Armyworm larvae. *Heliyon,* 10(20), e39593.

Selvakumar, S., Vimalanban, S & Balakrishnan, G. (2019). Quantitative determination of phytochemical constituents from *Anisomeles malabarica*. *MOJ Bioequivalence and Availability.* 6 (2), 19–21.

Sisay, B., Tefera, T., Wakgari, M., Ayalew, G. & Mendesil, E. (2019). The efficacy of .selected synthetic insecticides and botanicals against Fall Armyworm, *Spodoptera frugiperda*, in maize', *Insects*, 10 (2), 45-58.

Souza, C. M., Baldin, E. L. L & Ribeiro, L. P. (2017). Lethal and growth inhibitory activities of *neotropical Annonaceae*-derived extracts against *Helicoverpa armigera. J. Pest Sci.* 90:449–459. https://doi.org/10.1007/s10340-016-0763-2

Ujah, I. I., Nsude, C. A., Ani, O. N., Alozieuwa, U. B., Okpako, I. O. & Okwor, A. E. (2021). Phytochemicals of neem plant (*Azadirachta indica*) explains its use in traditional medicine and pest control. *Biological and Pharmaceutical Sciences,* 14(02), 165-171.

Wang, Y.,Meng, G., Chen, S., Chen, Y. & Jiang, J. (2018). Correlation analysis of phenolic contents and antioxidation in yellow and black seeded *brassica napus* , *Molecules*, 223 (7), 1815.

Zavala-Sánchez, M. A., Rodríguez-Chávez, J. L., Figueroa-Brito, R., Quintana-López, C. M.,Bah, M. M., Campos-Guillén, J., Bustos-Martínez, J. A., Zamora-Avella, D. & Ramos-López, M. A. (2019). Bioactivity of 1-octacosanol from *Senna crotalarioides* (Fabaceae: Caesalpinioideae) to control *Spodoptera frugiperda* (Lepidoptera: Noctuidae). *Florida Entomologist*, 102(4), 731-737.