Bio-Efficacy of Seed and Leaf Extracts of Azadirachta indica (neem) and Jatropha curcas (physic nut) against Fall Armyworm (Spodoptera frugiperda) Infestation in Maize Fields

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Bio-Efficacy of Seed and Leaf Extracts of *Azadirachta indica* (neem) and *Jatropha curcas* (physic nut) against Fall Armyworm (*Spodoptera frugiperda*) Infestation in Maize Fields

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Abstract

Background: The Fall armyworm, originally indigenous to the tropical and subtropical regions of the Americas, causing significant reductions in maize productivity. This study evaluated the bio-efficacy of seed and leaf extracts of *Azadirachta indica* (neem) and *Jatropha curcas* (physic nut) against Fall armyworm infestation under field conditions. The experiment was arranged in a randomized complete block design with five treatments. *A. indica* seed extract (SEAI), *A. indica* leaf extract (LEAI), *J. curcas* seed extract (SEJC), *J. curcas* leaf extract (LEJC) and an untreated control. The treatment were applied at a concentration of 150 g/L and replicated three times. Data were collected on larval populations, percentage infestation, leaf damage and grain yield.

Results: Results showed that, SEAI significantly reduced FAW larval population to 0.67 larvae per 10 maize plants after the third spray and recorded the lowest maize damage (10.0%,), in comparison, with untreated control plots (66.7%). The maize plots treated with seed extract of *Azadirachta indica* exhibited the lowest leaf damage score of 1.33. Grain yield was significantly enhanced by botanical treatments with SEAI producing the highest yield (2781.73 kg/ha), followed by SEJC (2581.73 kg/ha), LEAI (2541.67 kg/ha), and LEJC (2180.20 kg/ha) while untreated control yielded 1666.10 kg/ha.

Conclusion: This suggests that *A. indica* and *J. curcas* extracts may serve as alternatives for synthetic insecticides for the management of Fall armyworm to enhance maize yields.
Keywords: Botanicals, Fall armyworm, larval population, maize damage, grain yield,

Introduction

The Fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae), is indigenous to tropical and subtropical areas of the Americas and is the principal insect pest of maize in these locations (Putri & Aini, 2021). Fall armyworm (FAW) was initially reported in Africa in late 2016 in West Africa (Putri & Aini, 2021). This insect pest is highly polyphagous, infesting over 80 plant species, such as maize, sorghum, millet, sugarcane, and several vegetable crops (Nam *et al.,* 2024). The larvae stage inflict significant damage on maize by feeding on leaf tissues, young larvae initially consume the epidermal layers of leaves, causing characteristic windowing symptoms, while older larvae create irregular holes and extensive foliar damage, feeding within the whorl of young plants can injure the apical meristem, resulting in dead heart formation and reduced plant vigor (Mallesh *et al.,* 2024). In mature plants, the bigger larvae within the whorls might consume maize cobs or kernels, hence diminishing yield and quality (Ismail, 2024).

Recent estimates indicate that, without management measures, FAW might result in annual losses of 8.3 to 20.6 million tonnes of maize across 12 maize-producing nations (Prasoona *et al.,* 2022). Historically, the majority of smallholder farmers utilised plant materials for pest management, but, with the advent of synthetic pesticides, which peasant farmers deemed more efficacious, the traditional method was abandoned in favour of synthetic alternatives. The widespread application of chemical pesticides has adversely impacted beneficial insects, wildlife, and human health globally, while insect resistance to these pesticides has proliferated (Landge *et al.,* 2022).

Bio-pesticides serve as an excellent alternative to conventional pesticides due to their durability and minimal effects on animals and the environment (Landge *et al.,* 2025). *Azadirachta indica* contains several biologically active compounds, particularly azadirachtin, which possesses strong antifeedant, insect growth-regulating, repellent, and insecticidal properties, making it an effective botanical agent for pest management (Kim, 2021) similarly, *Jatropha curcas* contains bioactive compounds such as phorbol esters, alkaloids, flavonoids, and other secondary metabolites with insecticidal properties (Muniz *et al.,* 2020).

However, there is still insufficient information regarding the comparative field effectiveness of seed and leaf extracts of these botanicals against Fall armyworm infestations. Therefore, this study evaluated the bio-efficacy of seed and leaf extracts of *A, indica* and *J. curcas* in suppressing FAW population and infestation in maize field.

Materials and Methods

Description of the experimental site

The field experiment was conducted from May to July 2025 in Gbanchitako hamlet, situated in the Lavun Local Government Area of Southern Niger state, Nigeria. The region is situated between latitudes 8° and 10° north of the Equator and longitudes 3° and 8° east of the Greenwich Meridian in which the vegetation is dominated by guinea savanna, characterised by tall grasses and scattered shrubs and trees with average monthly temperatures ranging from 23°C to 29°C and annual precipitation between 1000 and 1600 mm (Mohammed *et al.,* 2020) and the monthly average temperature is between 23^0 and 29^0 degrees Celsius.

Land preparation and Sowing of the Maize grains

The land was cleared and ridges were manually made while the Niger white maize variety was sowed at a depth of 2 cm on the created ridges. Three seeds were planted per hill and subsequently reduced to two seeds per hole. Weeding was conducted manually with a hoe two weeks after seedling emergence and after four weeks, NPK 20:10:10 fertiliser was applied (Sisay *et al.,* 2019). Application of urea to fulfil the nitrogen requirements of maize at 28 days.

Experimental Design

The field experiment was carried out using a randomised complete block design with three replications as shown in Table 1. Each block was subdivided into six elementary plots, each measuring 32 m² (4 m x 8 m in length and breadth, respectively). The distance between the plots was 1 meter, between the blocks or replicates was measured 1.5 meters, between plants was 20 centimetres, and between rows was measured 60 centimetres.

Table 1: Experimental design

Treatment	Block A/replicate	Block B/replicate	Block C/replicate
T1	SEAI	SEJC	EMMB
T2	SEJC	CNTR	SEAI
T3	LEAI	SEAI	LEAI
T4	LEJC	EMMB	CNTR
T5	EMMB	LEAI	LEJC
T6	CNTR	LEJC	SEJC

T1-Seed extract of *Azadirachta indica* (SEAI) T2-Seed extract of *Jatropha curcas* (SEJC)
T3- Leaves extract of *Azadirachta indica* (LEAI) T4- Leaves extract of *Jatroph curcas* (LEJC)
T5- Emamectin benzoate (EMMB) T6- Untreated control (CNTR)

Preparation and Application of Botanical extracts

The leaves and seeds of *Azadirachta indica* (Neem) and *Jatropha curcas* (Physic nut) were obtained from the Biological Garden of Federal Polytechnic Bida, Niger State, Nigeria and subsequently brought to the laboratory of the Department of Animal Biology at the Federal University of Technology, Minna Niger State, Nigeria. The botanical specimens were identified by a botanist at the Department of Plant Biology, Federal University of Technology Minna. Voucher specimens of the plant material were submitted at the Herbarium of the Department of Animal Biology, Federal University of Technology Minna Nigeria for referencing. The various plant components were sectioned, rinsed with distilled water, and air-dried at a room temperature of 27±2°C for two weeks until achieving a constant weight (Boica *et al.,* 2020). The collected plant materials were ground into a fine powder using an electric blender. One hundred fifty grams of each plant powder was soaked in one litre of tap water for 24 hours. The liquid was stirred with a glass rod at 12 hour intervals. The mixture was filtered through double-layered muslin cloth, and the resulting filtrate was stored in a separate container for future use. All plant extracts and the synthetic insecticides (*Emamectin benzoate* WG at 0.5g/l) were administered three times at seven-day intervals (Mbaidiro & Onzo, 2022), commencing 25 days after sowing

(DAS) and subsequently at 32 DAS and 39 DAS using a knapsack sprayer. This was done to ensure comprehensive coverage of the maize plants, particularly the leaves and whorl. After each application, the sprayer was meticulously cleaned with liquid soap followed by water before transitioning between products to prevent contamination and eliminate bias in the results (Mbaidiro & Onzo, 2022). The maize plots were sprayed in late evening between 5:00 and 6:30 PM. The control maize plots were sprayed with water.

Data collection

Effect of selected botanicals on larvae population and maize damaged caused by Fall armyworm (*S. frugiperda*)

A visual observation of the number of live larvae and maize infestation were recorded 1day before and at 7 days after each treatment on 10 randomly selected maize plants from each experimental plot or unit (Sharanabasappa *et al.,* 2020). The percentage of maize infestation affected by Fall Armyworm was determined as outlined by (Mukanga *et al.,* 2022).

$$\%\ \text{Maize infestation} = \frac{Number\ of\ \text{maize}\ plants\ damaged}{Total\ number\ of\ \text{maize}\ plants\ sampled} \times 100$$

Maize leaf damaged or Foliar damage by Fall Armyworm

Ten maize plants were randomly selected from each plot and assessed before treatment application to establish baseline infestation levels. Post-treatment observations were recorded seven days after spraying to evaluate the efficacy of the botanical extracts against Fall armyworm infestation (Ismail, 2024). The extent of leaf damaged caused by larvae of Fall armyworm was estimated through visual scoring in 1-5 scale as described by Toepfer *et al.* (2021). The rating scale are: 1. Nil damage to pin hole damage, 2. Circular / elongated holes less than 1 inch. on whorl leaves, 3. Elongated holes > 1 inch. on whorl leaves, 4. Elongated holes 1-2 inch. and mild shredding on whorl leaves, 5. Severe shredding and defoliation.

Assessment of grain yields and grain yields increase

Grain yield was estimated by collecting maize cobs from ten randomly selected plants in each plot at maturity. The cobs were shelled and the grains dried to a uniform moisture content (12-14%) before weighing and yield determination (Usman *et al.,* 2022). The grain yield for each plot was estimated and converted to hectares using the formula.

$\text{Grain Yield (Kg/ha)} = \frac{\text{Yield/Plot} \times 10{,}000\text{m2}}{\text{Plot Size}}$ The percentage yield increase over control was calculated using the formula (Mbaidiro & Onzo, 2022; Kalinge *et al.,* 2024)

$$\% \text{ Grain Yield Increase} = \frac{Yield\ in\ treatment\ over\ control}{Yield\ of\ the\ control} \times 100$$

Statistically Analysis

Data with regard to larvae population, maize infestation, leaf damage and grain yields were analysed using analysis of variance (ANOVA), where significant differences were identified, mean values were differentiated through Duncan's Multiple Range Test at a 0.05 probability level, utilising the Statistical Package for the Social Sciences (SPSS) software (20th Version).

Results

Effect of seed and leaf extracts of *Azadirachta indica* and *Jatropha curcas* at concentration of 150g/l against population of Fall armyworm larvae in the fields

The effect of seed and leaf extracts of *Azadirachta indica* and *Jatropha curcas* at concentration of 150g/l against population of Fall Armyworm larvae in the fields are presented in figure 1. The pre- treatment observation of larvae population of FAW showed no significant ($p > 0.05$) difference, ranged between mean of 5.00 to 5.56 larvae per 10 maize plants. The post-treatment observation of the larvae population after the first sprayed of the botanical extracts varied from 2.67 to 6.33 larvae per 10 maize plants. There were no significant ($p > 0.05$) differences among the three botanical extracts (SEAI, LEAI and SEJC) and EMMB. The maize plot treated with SEAI recorded the least population of FAW (2.67 larvae /10 maize plants) which were not significant different with EMMB. Maize plants treated with LEAI recorded mean of 3.67 larvae/10 maize plants, followed by SEJC which recorded mean of 4.33 larvae/10 maize plants and LEJC recorded mean of 6.33 larvae/10 maize plants which showed no significant ($p > 0.05$) different with untreated control. After the second sprayed of maize plants, there were significant ($p < 0.05$) differences among the botanical extracts, maize plot treated with SEAI recorded mean of 1.33 larvae/10 maize plants, followed by LEAI which recorded 2.00 larvae/10 maize plants and SEJC recorded mean of 3.67 larvae/10 maize plants while LEJC recorded 5.00 larvae/ 10 maize plants and the untreated control recorded the highest mean of 6.67 larvae/10 maize plants while EMMB recorded mean of 0.67 larvae/10 maize plants. At third sprayed, there were no significant ($P > 0.05$) differences among SEAI, LEAI and EMMB. The maize plots treated with SEJC and LEJC recorded mean larvae population of 1.67 and 3.67 larvae/10 maize plants respectively and untreated control recorded the highest mean of 7.33 larvae/10 maize plants.

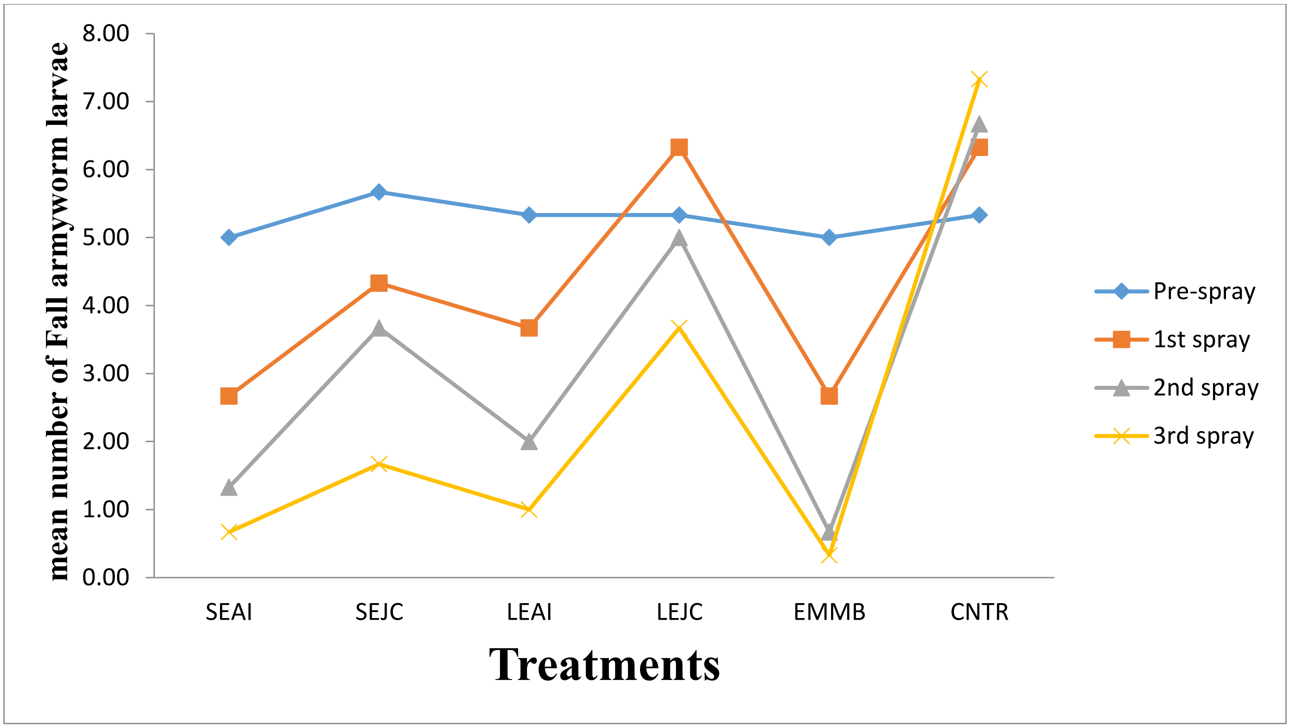

Figure 1: Mean number of Fall armyworm larvae treated with seed and leaf extract of *A. indica* and *J. curcas* at concentration of 150g/l

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 = Emamectin benzoate; CNTR = Untreated Control

Percentage maize infestation caused by Fall armyworm treated with different botanical extracts at concentration of 150g/l in the field

Figure 2 showed the percentage of maize infestation caused by FAW treated with various botanical extracts at a concentration of 150 g/l. The results indicated that, there were no significant differences ($p > 0.05$) in the percentage maize infestation during the pre-spray period. The efficacy of certain botanical extracts against maize infestation caused by FAW shown a significant difference ($p < 0.05$) among the three treatments (SEAI, SEJC and LEAI) and LEJC following the initial application on maize plots. Maize infestation in maize plots treated with SEAI, SEJC, LEAI and EMMB were diminished relative to the untreated control. The maize damaged varied from 16.7% to 30% among the botanical extracts, while the control exhibited an maize infestation increase of 40%. In the second treatment application, the highest reduction of maize infestation was noted in maize plot treated with SEAI (13.3%), but SEJC and LEJC exhibited maize infestation of 20% and 26.7%, respectively, in comparison to the control group, which recorded 56.7% while EMMB showed a 10% maize infestation. Following the third treatment application, the maize infestation varied from 6.67% to 66.7%. No significant difference ($p > 0.05$) was observed between SEJC and LEAI. The maize infestation of 10% was recorded in maize plots treated with SEAI and 13.3%, 16.7%, and 26.7% were recorded in maize plots treated with LEAI, SEJC, and LEJC, respectively, while the lowest maize infestation was recorded in EMMB at 6.67%, in contrast to the untreated control at 66.7%..

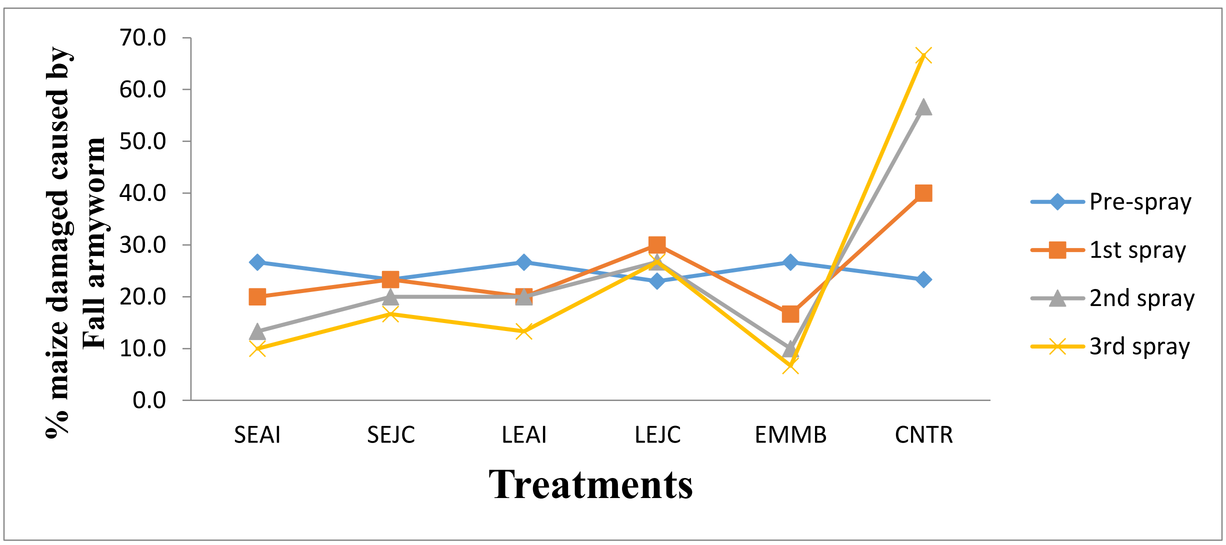

Figure 2: Percentage maize damaged caused by Fall armyworm after treatment with different botanical extracts at Concentration of 150g/l in the field

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 = Emamectin benzoate; CNTR = Untreated Control

Effects of botanical extracts at concentration of 150g/L on leaf damaged inflicted by Fall Armyworm in the fields

The impact of botanical extracts at a concentration of 150g/L on leaf damage caused by FAW is illustrated in Figure 3. Results indicated that leaf damage produced by FAW larvae did not differ substantially ($p > 0.05$) across treatments prior to spraying, as assessed by the leaf damage rating score. Nevertheless, the leaf damage assessment scores varied significantly among the treatments following the first, second, and third applications. The leaf damage rating score was highest in the untreated control and lowest in the majority of the treatments. Following the initial application of botanical extracts, no significant differences were observed across all treatments, each registering a leaf damage rating score of 2.33 for SEJC and LEAI, while SEAI, LEJC, and EMMB recorded scores of 2.0, 2.67, and 1.67, respectively, in comparison to the control, which recorded a value of 3.67. At the second spray, there was no significant difference between SEAI and LEAI, both recording a leaf damage rating score of 1.67, while SEJC and LEAI reported scores of 2.0 and 2.33, respectively, in comparison to the control, which recorded 4.00. Following the third application, the effectiveness of SEAI and EMMB did not exhibit significant differences, although LEAI and SEJC recorded scores of 1.67 and 2.00, respectively, and the untreated control displayed a substantial leaf damage rating of 4.67. The total mean ratings for leaf damage were 1.67, 1.89, 2.11, and 2.44 in SEAI, LEAI, SEJC, and LEJC, respectively, while EMMB and the control received ratings score of 1.33 and 4.11, respectively.

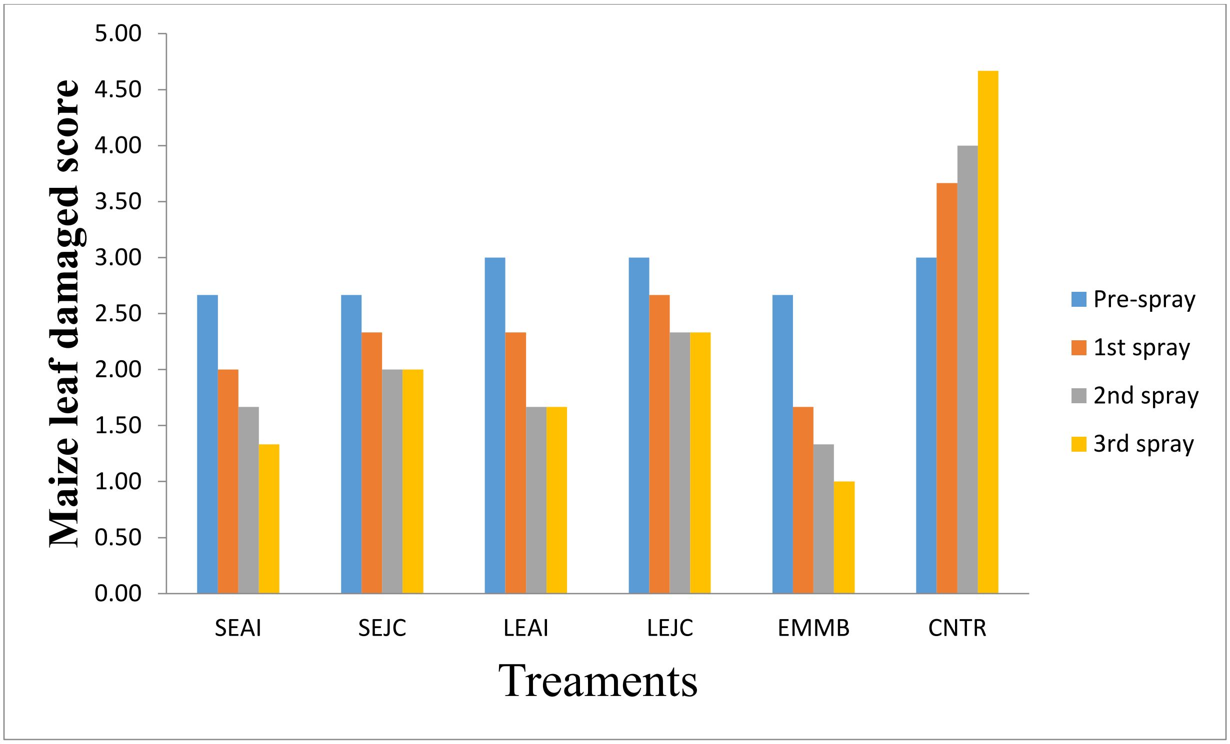

Figure 3: Leaves damaged scoring after treated with botanical extracts at conc. of 150g/l

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 = Emamectin benzoate; UCNTR = Untreated Control

Grain yields and increased yields of treatments over control in the field

Table 2 illustrates the grain yield recorded under each treatment and the corresponding yield enhancement compared with the control treatment, The results showed that, maize grain yields were significantly ($p < 0.05$) affected by the treatments evaluated. All applications of botanical extracts demonstrated superior grain yields compared to control maize plots. The grain yields from the botanical extracts varied from 2180.20 kg/ha to 2781.73 kg/ha and grain yields increased ranging from 514.21 kg/ha to 1115.63 kg/ha. The maize plots treated with SEAI exhibited the highest grain yields among the treatments, recording 2781.73 kg/ha, representing an increase over the control yield of 1115.63 kg/ha. No significant difference ($p > 0.05$) was observed between the values obtained from SEJC and LEAI. Seeds extract of *J. curcas* recorded grain yields of 2581.67 kg/ha, reflecting an increase of 915.53 kg/ha over the control, while maize plot treated with LEAI yielded 2541.67 kg/ha, with an increase of 875.59 kg/ha. In contrast, maize plots treated with LEJC produced grain yields of 2180.20 kg/ha, showing an increase of 514.10 kg/ha over the control. The maize plot treated with EMMB documented grain yields of 2806.15 kg/ha, reflecting an increase of 1140.05 kg/ha. The grain yields from maize plants in these treatments was substantially greater than that of untreated control plants (1666.10 kg/ha).

Table 2: Mean grain yields and increase yields of treatments over the control in the fields

Treatment	Grain yields after harvesting (kg/ha)	Grain yields increase over control (kg/ha)
Seed extract of *A.indica*	2781.73 ± 0.09^{d}*	1115.63^{d}
Seed extract of *J. Curcas*	2581.67 ± 0.07^{c}	915.53^{c}
Leaf extract of *A. indica*	2541.67 ± 0.13^{c}	875.59^{c}
Leaf extract of *J. Curcas*	2180.20 ± 1.80^{b}	514.1^{b}
Emamectin benzoate 5 %	2806.15 ± 0.08^{e}	1140.05^{e}
Untreated control 0 %	1666.10 ± 5.33^{a}	0.00^{a}

* Values followed by the same superscript alphabets in a column are not significantly different at P > 0.05.

Discussion

All the botanical extracts remarkedly suppressed the population of FAW in the fields. The findings of this study indicate that treatment with SEAI, SEJC, LEAI and LEJC demonstrated considerable efficacy and may serve as viable alternatives to Emamectin benzoate, a synthetic insecticides, which is widely recognized as effective control agent against FAW (Deshmukh *et al.,* 2020). The effectiveness of *A. indica* and *J. curcas* has already been reported by many authors in the management of FAW. Sisay *et al.* (2019) demonstrated in both laboratory and field trials, the efficacy of seeds of *A. indica* and *J. curcas* against FAW and efficacy of Neem oil against FAW has also been reported by several other authors (Phambala *et al.,* 2020; Aniwanou *et al.,* 2021). The maize plot treated with SEAI recorded the lowest larvae population after the third spray. The superior insecticidal activity exhibited by neem seed extract could be attributed to the abundance of Azadirachtin and other bioactive limonoids, that adversely affect feeding, metamorphosis, and reproduction in insects (Pavela *et al.,* 2024). Siazemo & Simfukwe (2020) reported that, neem extract was effective in reducing the FAW larvae population as compared to other botanical extracts. Mean larvae population of 0.67 reported in this study after treatment with SEAI was similar with those of Mazed *et al.* (2022) who reported mean larvae of 0.40 on treated maize plot with neem seed kernel. Jeanne *et al.* (2022) demonstrated that, neem oil extract was effective in reducing the incidence, decreasing the larvae population of FAW in the field.

Maize infestation by FAW substantially reduced in all maize plots treated with the botanical extracts, indicating their effectiveness in suppressing pest populations and minimizing crop damage. The lowest maize infestations were observed in maize plots treated with SEAI, similar with the findings of Mazed *et al.* (2022), who demonstrated that, maize plots treated with neem seed extract showed a significant decline in FAW infestation during the vegetative growth stages. Sisay *et al.* (2019) indicated that the utilisation of neem extracts at 32 and 39 days resulted in the minimal infestation of Fall armyworm in maize fields. The minimal infestation in maize plants treated with neem seed extract is ascribed to the enhanced insecticidal efficacy of the treatment against FAW larvae, mostly through feeding inhibition, growth deterrent, disruption, and increased larval death (Kebede *et al.,* 2024). An maize plant infestation rate of 16.7 percent was observed in maize plots treated with SEJC. The resulting value was lower to that reported by Okello *et al.* (2025). The discrepancies in the findings may be ascribed to variations in climatic conditions such as rainfall distribution and temperature (Mazed *et al.,* 2022). Botanicals diminished the larval population, resulting in decreased maize damage during the vegetative growth and cob stages, which facilitated enhanced crop growth and photosynthesis, ultimately yielding significantly higher maize outputs compared to unprotected plants (Tanyi *et al.,* 2020).

All treatments revealed a significantly lower reduction in leaf damage. Maize plots subjected to SEAI and LEAI treatment had the lowest leaf damage rating scores, ranging from 1.33 to 1.67, following the third application. The findings of this study align with those of Sisay *et al*. (2019), who demonstrated that maize plots treated with neem seed extracts exhibited reduction of leaf damage by Fall Armyworm, whereas untreated maize plots experienced significant leaf damage at both 32 and 39 days. Conversely, leaf damage of 1.33 and 1.67 was noticed in maize plots treated with SEAI and LEAI, respectively, both of which were lower than the 1.73 reported by Gebretsadkan & Weldu (2024). This may pertain to variations in extract concentration or duration of treatment exposure. The untreated control experiment registered the highest leaf damage rating of 4.67, indicating that elevated leaf damage scores adversely impact the plant's photosynthetic activities, resulting in decreased productivity. Usman *et al*. (2022) established that FAW damage does not cause significant leaf injury to the crop to the degree that yield is critically affected; however, substantial yield losses typically arise when the leaf whorl is compromised and the photosynthetic area is diminished.

The significantly higher grain yield observed in this study, especially in plots treated with SEAI, may be attributed to its strong insecticidal activity, which effectively reduced *Spodoptera frugiperda* infestation and crop damage. Consequently, the plants maintained greater leaf integrity and photosynthetic efficiency, leading to improved growth and increased grain production. The maximum grain yields (2781.73 kg/ha) was seen in maize plots treated with

SEAI. This value exceeded the 2446 kg/ha reported by Dhobi *et al.* (2020) but fell short of the 5864 kg/ha reported by Mazed *et al.* (2022). The discrepancies may be ascribed to ecological factors such as plant diversity, rainfall distribution, temperature, relative humidity, or the method of extraction of plant materials. Likewise, earlier researchers have documented enhanced yields of various crops treated with *A. indica* and *J. curcas* for insect pest management (Kammo *et al.,* 2019; Aniwanou *et al.,* 2021). The grain yields achieved (2581.61 kg/ha) in SEJC during this study surpassed the figure (1500 kg/ha) documented by Mbaidiro *et al.* (2022), The results of this study, which showed positive protective effects, the biopesticides tested, can safely be incorporated in Integrated Pest Management strategies against FAW by smallholders farmers.

Conclusion

All evaluated botanical extracts are efficacious in reducing the FAW population and maize damaged caused by Fall armyworm (*S. frugiperda*), specifically, seed extracts of *Azadirachta indica* gave protection comparable to that of *Emamectin benzoate*, resulting in enhanced grain yields. The maize plot treated with SEAI recorded the lowest larvae population of 0.67 larvae per ten maize plants, maize damaged of 10% and grain yield of 2781.73 kg/ha. The botanicals provide an exceptional eco-friendly alternative to synthetic insecticides for the management of FAW larval pests and increased the grain yields.

Abbreviations

Seed extract of *Azadirachta indica* (SEAI)

Seed extract of *Jatropha curcas* (SEJC)

Leaves extract of *Azadirachta indica* (LEAI)

Leaves extract of *Jatroph curcas* (LEJC)

Emamectin benzoate (EMMB)

Untreated control (CNTR)

Fall Armyworm (FAW)

Declarations

Ethics approval and consent to participate

Not applicable

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

Data availability and materials

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

Conflict of interest

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

Funding

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Authors contributions.

Cece, M. A: collection of the data,, writing the first draft, Olayemi, I. K: Concentualised 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.

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Supplementary Files

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