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Insecticidal activity of Philippine cherry (*Syzygium lineatum* (D.C. Merr & L.M. Perry) leaf extract against the fall armyworm (*Spodoptera frugiperda*)

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Abstract
The search for environmentally friendly alternatives to synthetic pesticides has led to increasing interest in plant-derived insecticides. This study evaluated the insecticidal activity of leaf extracts from Philippine cherry against the fall armyworm, *Spodoptera frugiperda*, a destructive pest affecting major crops. Leaves were collected, dried, and extracted using methanol through maceration. Preliminary phytochemical screening was conducted to identify bioactive compounds. Bioassays were performed using different concentrations of the extract against third instar larvae of *S. frugiperda*. Mortality rates were recorded after 24 and 48 hours. Results indicated that the extract exhibited dose-dependent insecticidal activity. Phytochemical analysis revealed the presence of flavonoids, alkaloids, tannins, and phenolic compounds which may contribute to insect toxicity. Statistical analysis using ANOVA showed significant differences among treatments ($p < 0.05$). The findings suggest that *S. lineatum* leaf extract has potential as a botanical insecticide.

Keywords: Botanical pesticide, fall armyworm, plant extract toxicity, phytochemicals, bioassay

Introduction

The fall armyworm, *Spodoptera frugiperda*, is one of the most destructive agricultural pests affecting crops such as corn, rice, and sorghum. The pest has caused substantial economic losses worldwide because of its high reproductive capacity, wide host range, and increasing resistance to many synthetic insecticides. The widespread use of chemical pesticides has also raised serious concerns regarding environmental contamination, pest resistance, and potential health risks to humans and non-target organisms. Consequently, the search for safer and sustainable pest management strategies has become a major focus in modern agriculture.

One promising alternative is the use of botanical insecticides derived from plants. These plant-based pesticides are considered environmentally friendly because they are biodegradable, less persistent in the environment, and generally less toxic to beneficial organisms compared to synthetic chemicals. Studies have demonstrated that various plant extracts can effectively control agricultural pests, including the fall armyworm, through toxic, repellent, or growth-inhibiting effects. Botanical extracts have been shown to cause significant larval mortality and developmental disruption in *S. frugiperda*, highlighting their potential role in integrated pest management programs.

Plants naturally produce a wide range of secondary metabolites that function as defense compounds against herbivores and pathogens. These bioactive substances include alkaloids, flavonoids, tannins, terpenoids, and phenolic compounds, many of which possess insecticidal, antifeedant, or growth-regulating properties. Such compounds interfere with insect physiological processes, leading to reduced feeding, inhibited development, or mortality.

Among plants with promising bioactive properties is *Syzygium lineatum*, a member of the Myrtaceae family commonly known as Philippine cherry. Plants within the genus *Syzygium* are known to contain a variety of phytochemicals such as flavonoids, phenolics, alkaloids, and tannins, which exhibit antimicrobial, antioxidant, and other biological activities. Although several species in the genus have been investigated for biological activity, limited studies have explored the insecticidal potential of *S. lineatum*, particularly against economically important pests such as the fall armyworm.

Therefore, this study aims to evaluate the insecticidal activity of *S. lineatum* leaf extract against *S. frugiperda* larvae. Specifically, the study seeks to prepare crude leaf extracts, determine the phytochemical constituents present in the extract, and assess the insecticidal activity of different extract concentrations against fall armyworm larvae. Mortality rates will be measured and statistically analyzed to determine the effectiveness of the extract as a potential botanical insecticide. The findings of this research may contribute to the development of environmentally sustainable pest management strategies for agricultural systems.

Materials and methods

Plant Materials

Fresh leaves of *Syzygium lineatum* were collected from mature plants growing in Echague, Isabela, Philippines (Figure 1). The plant species was authenticated by a plant taxonomist to ensure proper identification. The collected leaves were washed thoroughly with distilled water to remove dust and contaminants. After washing, the leaves were air-dried at room temperature for approximately 7–10 days until a constant weight was obtained.

The dried plant material was pulverized using a mechanical grinder to obtain fine powder suitable for extraction.

Fig 1: The Philippine cherry plant

Preparation of Plant Extract

A 200 g of powdered leaf material was soaked in 95% methanol using the maceration method. The mixture was stored in a clean glass container and allowed to stand for 72 hours with occasional shaking to facilitate the extraction of bioactive compounds.

After maceration, the extract was filtered using Whatman No. 1 filter paper to separate the plant residues from the solvent extract. The filtrate was then concentrated using a rotary evaporator under reduced pressure to remove the solvent and obtain a crude methanolic extract. The crude extract was stored in sterile containers at 4°C until further use.

Phytochemical Screening

Preliminary phytochemical screening was conducted to identify the presence of major secondary metabolites. Standard qualitative chemical tests were performed following established procedures [5]. The following compounds were tested:

Table 1: Phytochemical screening of *Syzygium lineatum* leaf extract

Phytochemical	Test Used
Alkaloids	Dragendorff's Test
Flavonoids	Shinoda Test
Tannins	Ferric Chloride Test
Saponins	Foam Test
Phenolic Compounds	Ferric Chloride Test
Terpenoids	Salkowski Test

The presence of these phytochemicals is important because many plants secondary metabolites possess biological activities including insecticidal properties.

Collection and Rearing of Test Insects

Larvae of *Spodoptera frugiperda* (fall armyworm) were collected from infested corn plants in nearby agricultural fields and transported to the laboratory in plastic containers. The insects were reared under laboratory conditions at room temperature and provided with fresh corn leaves until they reached the third instar stage. Third instar larvae were selected for the insecticidal bioassay because they are actively feeding and are the most suitable stage for toxicity testing.

Preparation of Test Solutions

Different concentrations of the *Syzygium lineatum* leaf extract were prepared by dissolving the crude extract in distilled water, with a small amount of ethanol used as a co-solvent. The concentrations tested in the experiment were 100 ppm, 250 ppm, 500 ppm, and 1000 ppm, with distilled water serving as the control. Each solution was freshly prepared prior to the start of the experiment to ensure consistency and accuracy in the bioassay.

Insecticidal Bioassay

The insecticidal activity of the plant extract was evaluated using a contact toxicity method. Fresh corn leaves were sprayed with the prepared extract solutions using a hand sprayer and allowed to air dry. Ten third-instar larvae of *Spodoptera frugiperda* were then placed in each treatment container containing the treated leaves. Each treatment was replicated three times to ensure reliability of the results. The larvae were observed at 24 and 48 hours post-treatment, and the number of dead larvae was recorded. Mortality percentage was calculated using the following formula:

$$\text{Mortality (\%)} = \frac{\text{Number of dead insects}}{\text{Total number of insects}} \times 100$$

Statistical Analysis

The experimental data were analyzed using descriptive statistics, including mean and standard deviation. Analysis of Variance (ANOVA) was performed to determine whether significant differences existed among the treatment groups. A significance level of $p < 0.05$ was considered statistically significant.

Results

Phytochemical Screening of *Syzygium lineatum* Leaf Extract

Table 1: Phytochemical screening of *Syzygium lineatum* leaf extract

Phytochemical	Test Used	Result
Alkaloids	Dragendorff's Test	+ (present)
Flavonoids	Shinoda Test	+ (present)
Tannins	Ferric Chloride Test	+ (present)
Saponins	Foam Test	+ (present)
Phenolic Compounds	Ferric Chloride Test	+ (present)
Terpenoids	Salkowski Test	+ (present)

+-indicates the presence of the respective secondary metabolite.

The presence of alkaloids, flavonoids, tannins, saponins, phenolic compounds, and terpenoids in *Syzygium lineatum* leaf extract suggests the potential for insecticidal activity, as many plants secondary metabolites are known to act as allelochemicals targeting insect physiology and behavior. Benelli & Maggi [1] describe how phenolics, terpenoids, and alkaloids can affect pest insects, while Farhan *et al.* [3] highlight the antifeedant and toxic effects of these metabolites against aphids and other herbivores. Additionally, saponins have been shown to play a role in plant defense and pest management [10].

Insecticidal Bioassay of *S. lineatum* Leaf Extract

The insecticidal activity was tested using third-instar larvae of *Spodoptera frugiperda* with extract concentrations of 100, 250, 500, and 1000 ppm. Mortality was observed at 24 and 48 hours post-treatment.

Table 2: Mortality (%) of *S. frugiperda* larvae after treatment with *S. lineatum* leaf extract

Concentration (ppm)	Mortality at 24 h (%)	Mortality at 48 h (%)
Control (distilled water)	0	0
100	10	25
250	25	45
500	45	65
1000	65	90

The data in Table 2 indicate a clear dose-dependent increase in mortality of *S. frugiperda* larvae treated with *S. lineatum* leaf extract, as mortality progressively increased with higher extract concentrations. No mortality was observed in the control (distilled water) at both 24 and 48 hours, indicating that larval deaths in the treatment groups were attributable to the extract. At 100 ppm, mortality was low but noticeable (10% at 24 h and 25% at 48 h), increasing at 250 ppm, and further rising at 500 ppm and 1000 ppm, with the highest concentration reaching 90% mortality at 48 hours. Mortality also increased over time, with higher percentages recorded at 48 h compared to 24 h at each concentration level, demonstrating a time-dependent effect of the extract. These trends are consistent with other botanical insecticidal studies showing that higher concentrations of plant extracts generally lead to increased larval mortality and that prolonged exposure enhances toxic effects against *S. frugiperda* larvae — for example, *Azadirachta indica*, *Eucalyptus globulus*, *Parthenium hysterophorus*, *Cannabis sativa*, *Citrullus colocynthis*, and *Nicotiana tabacum* extracts caused greater mortality at higher concentrations and longer exposure periods in third-instar fall armyworm larvae compared to controls [9], and similar dose-dependent mortality increases were reported in contact toxicity bioassays with botanical extracts (e.g., *Tagetes erecta* and *Datura metel*) where percent mortality rose with increasing concentrations of extracts tested against *S. frugiperda* larvae.

Dose-Dependent Response

Mortality increased with increasing extract concentration, showing a clear dose-dependent response. The highest concentration (1000 ppm) caused 90% mortality at 48 hours.

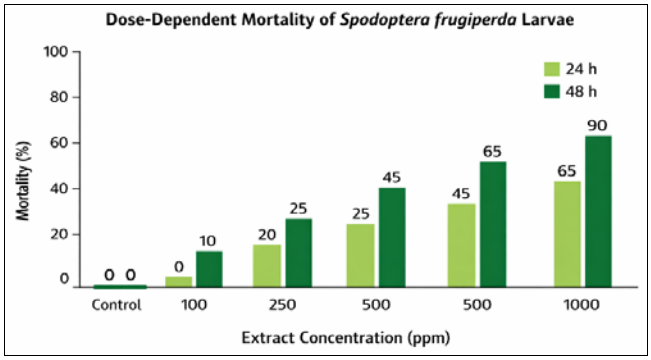

Fig 2: Mortality rate of *S. frugiperda* larvae exposed to *S. lineatum* leaf extract.

Mortality of *S. frugiperda* larvae increased with increasing concentrations of *S.* leaf extract, demonstrating a clear dose-dependent response. The highest concentration (1000 ppm) caused 90% mortality at 48 hours (Figure 2). This pattern is consistent with findings from Saleem *et al.* [9], who reported that ethanolic extracts of *Azadirachta indica*, *Eucalyptus globulus*, and *Parthenium hysterophorus* caused significantly higher mortality in third-instar *S. frugiperda* larvae at higher concentrations compared to controls [9]. Similar dose-dependent effects were observed in studies using *Tagetes erecta* and *Datura metel* leaf extracts, where mortality increased progressively with higher extract concentrations [2].

Discussion

The results of this study demonstrated that the methanolic leaf extract of *S. lineatum* exhibited insecticidal activity against *S. frugiperda* larvae. Mortality increased with higher extract concentrations, indicating a dose-dependent response, with the highest concentration producing the greatest mortality after 48 hours of exposure.

The observed insecticidal activity may be attributed to the presence of phytochemical constituents identified during preliminary screening. Compounds such as flavonoids, alkaloids, tannins, and phenolic compounds are known to exert toxic effects against insects. These secondary metabolites may interfere with the insect nervous system, disrupt metabolic processes, or act as feeding deterrents.

According to Isman [4], plant secondary metabolites function as natural defense mechanisms against herbivorous insects. Botanical insecticides derived from plants are increasingly recognized as sustainable alternatives to synthetic pesticides because they are biodegradable and pose less risk to the environment. Similarly, Pavela [8] reported that plant extracts containing phenolic and terpenoid compounds can exhibit strong insecticidal and repellent properties against various agricultural pests by affecting insect growth, development, and reproduction.

Studies on the genus *Syzygium* have also shown that plants in this group contain bioactive compounds with antimicrobial and insecticidal activities. Manicad and Pattung [6] reported that *Syzygium lineatum* leaf extracts contain phenolics, tannins, and flavonoids that contribute to their biological activity. The results of the present study are consistent with these findings, supporting the potential of plant extracts as effective agents for controlling insect pests.

The fall armyworm (*Spodoptera frugiperda*) is a major agricultural pest responsible for significant crop losses worldwide. Therefore, the use of plant-based insecticides,

such as *S. lineatum*, may provide a promising alternative for sustainable pest management.

However, further studies are needed to isolate and identify the specific compounds responsible for the insecticidal activity. Advanced analytical techniques, such as gas chromatography–mass spectrometry (GC–MS), may be employed to determine the chemical composition of the extract. In addition, field trials should be conducted to evaluate the effectiveness of the plant extract under natural agricultural conditions.

Conclusion

The study demonstrates that *Syzygium lineatum* leaf extract exhibits significant insecticidal activity against third-instar *Spodoptera frugiperda* larvae. Mortality increased with both extract concentration and exposure time, showing a clear dose- and time-dependent response. The highest concentration tested (1000 ppm) resulted in 90% larval mortality at 48 hours, while the control group showed no mortality, confirming that the observed effects were attributable to the extract. These findings are consistent with previous studies on botanical insecticides, where higher concentrations of plant extracts such as *Azadirachta indica* and *Eucalyptus globulus* caused increased mortality in *S. frugiperda* larvae [7, 9]. *S. lineatum* leaf extract shows potential as a natural, eco-friendly alternative for managing fall armyworm infestations, supporting its use in integrated pest management strategies.

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