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Effect of Sodom Apple (*Calotropis procera*) Leaves and Siamese Cassia (*Senna siamea*) Leaves against Maize Weevils (*Sitophilus zemais*) Causing Damage on Maize Storage in Bauchi Environment

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Abstract

Maize (*Zea mays* L.) is a major cereal crop widely cultivated and consumed in Nigeria, serving as a staple food for humans, livestock feed, and raw material for agro-based industries. However, its storage is severely threatened by post-harvest losses caused mainly by insect pests, particularly the maize weevil (*Sitophilus zeamais*), which leads to significant quantitative and qualitative deterioration of stored grains. This study evaluated the insecticidal effectiveness of *Calotropis procera* (Sodom apple) and *Senna siamea* (Siamese cassia) leaf powders against maize weevils in stored maize under laboratory conditions in Bauchi environment, Nigeria. The experiment was conducted in the Agronomy Laboratory of the Department of Agricultural Technology, Federal Polytechnic Bauchi, using a Completely Randomized Design (CRD) with three treatments: 10 g of *Calotropis procera* leaf powder per 200 g of maize (T_1), 10 g of *Senna siamea* leaf powder per 200 g of maize (T_2), and an untreated control (T_3), each replicated three times. A total of 10 adult *S. zeamais* were introduced into each container and observations were recorded weekly for six weeks. Data collected included number of dead insects, number of live insects, and number of holes per seed. The data were analyzed using descriptive statistics and Analysis of Variance (ANOVA) at 5% probability level. Results showed that both botanical treatments significantly increased maize weevil mortality and reduced grain damage compared to the untreated control. *Senna siamea* consistently exhibited superior

insecticidal activity, recording the lowest mean number of live insects (10.5) and the least grain damage (1.2 holes per seed), while also achieving complete suppression of live insects at the end of the storage period. *Calotropis procera* also demonstrated considerable insecticidal properties but was less effective than *Senna siamea*. The control treatment recorded the highest insect survival and greatest grain deterioration throughout the study period. The ANOVA results confirmed significant differences ($p < 0.05$) among treatments for all parameters assessed. The study concludes that both plant powders possess insecticidal properties, with *Senna siamea* being more effective. Therefore, these botanicals can serve as affordable, eco-friendly, and sustainable alternatives to synthetic insecticides for maize storage protection in Bauchi environment.

Keywords: Sitophilus zeamais, Calotropis procera, Insecticide

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops cultivated globally and serves as a major source of food for humans, feed for livestock, and raw material for agro-based industries. In Nigeria and many parts of sub-Saharan Africa, maize plays a critical role in ensuring food security, income generation, and rural development due to its adaptability to diverse ecological conditions and high economic importance. Despite increased production efforts, post-harvest losses remain a major challenge affecting the availability, quality, and market value of stored maize grains (FAO, 2022).

Stored maize grains are highly vulnerable to infestation by storage insect pests, among which the maize weevil, *Sitophilus zeamais* Motschulsky, is regarded as one of the most destructive species. The pest causes both quantitative and qualitative losses through feeding and boring activities within the grains, resulting in weight reduction, reduced germination potential, contamination, and deterioration of nutritional quality. Infestation by *S. zeamais* also creates favorable conditions for the development of fungi and secondary pests, thereby accelerating grain spoilage during storage (Baoua *et al*., 2020; Udo *et al*., 2021).

According to recent studies, the rapid reproductive capacity and feeding activities of maize weevils significantly contribute to severe storage losses in maize-producing regions of Africa. Research findings have shown that *Sitophilus zeamais* remains the predominant insect pest responsible for substantial post-harvest maize damage in traditional and modern storage systems, leading to economic losses among smallholder farmers and grain traders (Gitonga *et al*., 2021; Midega *et al*., 2023). The increasing concern over the adverse effects of synthetic insecticides, including pest resistance, environmental pollution, and health hazards, has therefore encouraged the search for safer, eco-friendly, and sustainable alternatives for the management of storage pests.

The control of storage insect pests has traditionally relied on synthetic chemical insecticides such as permethrin and pirimiphos-methyl. Although effective, continuous use of these chemicals has raised serious concerns regarding environmental pollution, pest resistance, toxic residues in food grains, and health hazards to humans and animals. These challenges have created the need for safer, cheaper, and environmentally friendly alternatives for protecting stored maize (Emeasor *et al.*, 2023).

One of such promising plants is Calotropis procera commonly known as Sodom apple. The plant is widely distributed in the savannah regions of Nigeria including Bauchi State and is known for its medicinal and pesticidal properties. Different parts of the plant such as leaves, stem bark, roots, and latex contain bioactive compounds that have shown effectiveness against various insect pests. The abundance and accessibility of the plant make it a potential low-cost botanical insecticide for rural farmers.

Abubakar et al. (2020) evaluated the insecticidal activity of leaf and stem bark powders of Calotropis procera against maize weevils on stored maize. Their findings showed that application of 5 g leaf powder per 100 g maize significantly increased adult mortality, reduced oviposition, decreased grain damage, minimized exit holes, and reduced weight loss of maize grains during storage. The study further reported that treated maize seeds maintained good germination capacity, indicating that the plant material did not adversely affect seed viability. Furthermore, several studies on botanical protectants have demonstrated that plant powders and extracts from tropical species can effectively suppress storage pests. Negbenebor and Nura (2022) reported that plant extracts significantly reduced adult emergence and grain damage caused by maize weevils under storage conditions. Likewise, Muhammad and Babatunde (2021) observed that certain spices used as grain protectants caused high mortality of Sitophilus zeamais and reduced seed deterioration in stored maize.

PROBLEM STATEMENT

Maize (*Zea mays* L.) is one of the most important cereal crops cultivated and consumed in Nigeria because of its nutritional, industrial, and economic value. It serves as a major source of food for humans, feed for livestock, and raw material for agro-based industries. However, despite increased maize production, substantial post-harvest losses during storage remain a serious challenge to food security and farmers' income in Nigeria and other developing countries. One of the major causes of storage losses in maize is infestation by the maize weevil, Sitophilus zeamais, which damages stored grains through feeding and reproduction activities. The insect bores holes into maize grains, thereby reducing grain weight, nutritional quality, seed viability, and market value. Severe infestation may also encourage fungal growth and contamination of stored grains, resulting in quantitative and qualitative deterioration during storage (Mpoke *et al*., 2023).

To control storage insect pests, many farmers depend heavily on synthetic chemical insecticides. Although effective, continuous use of these chemicals has raised concerns regarding toxic residues in food grains, environmental pollution, pest resistance, high cost,

and health hazards to humans and animals (Emeasor *et al*., 2023; Akinfiresoye *et al*., 2024). Furthermore, most smallholder farmers in rural areas of Bauchi State cannot easily afford commercial pesticides or may lack proper knowledge regarding their safe handling and application.

As a result, attention has shifted toward the use of botanical insecticides that are biodegradable, affordable, locally available, and environmentally friendly. Several studies have shown that plant materials possess insecticidal and repellent properties against storage pests. For example, Okwuonu et al. (2023) reported that botanical extracts significantly reduced maize weevil infestation and grain deterioration during storage. Similarly, Gindaba et al. (2024) observed that medicinal plant powders exhibited strong insecticidal activities against *Sitophilus zeamais*.

Among the locally available plants in Bauchi environment are Calotropis procera and Senna siamea, which are believed to possess pesticidal properties due to the presence of bioactive compounds such as alkaloids, tannins, flavonoids, and saponins. However, there is limited documented information on their comparative effectiveness against maize weevils under storage conditions in Bauchi environment. Therefore, this study was conducted to evaluate the effectiveness of *Calotropis procera* and *Senna siamea* leaf powders in controlling maize weevils (*Sitophilus zeamais*) and reducing grain damage during maize storage in Bauchi environment.

General Objective

The general objective of this study is to evaluate the effectiveness of *Calotropis procera* and *Senna siamea* leaf powders against *Sitophilus zeamais* causing damage on stored maize in Bauchi environment.

Specific Objectives

The specific objectives of the study are to:

1. determine the effect of *Calotropis procera* leaf powder on the mortality of *Sitophilus zeamais* in stored maize;
2. determine the effect of *Senna siamea* leaf powder on the mortality of *Sitophilus zeamais* in stored maize;
3. compare the effectiveness of *Calotropis procera* and *Senna siamea* leaf powders in reducing the population of live maize weevils during storage;
4. assess the effect of the botanical treatments on grain damage by determining the number of holes per maize seed;
5. evaluate the overall effectiveness of the botanical powders as eco-friendly alternatives to synthetic insecticides for maize storage protection in Bauchi environment.

RESEARCH QUESTIONS

1. What is the effect of *Calotropis procera* leaf powder on the mortality of *Sitophilus zeamais* in stored maize?

2. What is the effect of *Senna siamea* leaf powder on the mortality of *Sitophilus zeamais* in stored maize?
3. Which of the two botanicals, *Calotropis procera* or *Senna siamea*, is more effective in reducing the population of live maize weevils during storage?
4. What effect do the botanical treatments have on grain damage measured by the number of holes per maize seed?
5. Can *Calotropis procera* and *Senna siamea* leaf powders serve as effective and environmentally friendly alternatives to synthetic insecticides for the control of maize weevils in stored maize?

RESEARCH METHODOLOGY

The research was conducted in the Agronomy Laboratory of the Department of Agricultural Technology, Federal Polytechnic Bauchi, Bauchi State, Nigeria. Bauchi is located in the northern Guinea savannah zone of Nigeria. The climate of the area is characterized by distinct dry and rainy seasons, with an annual rainfall ranging from 700 mm to 1,300 mm and a temperature range of 21°C to 39°C. The region supports a variety of vegetation and agricultural activities, including cowpea cultivation, which makes it a suitable location for this study. The experiment was laid out in a **Completely Randomized Design (CRD)** with two (2) treatments, each replicated three (3) times to ensure accuracy and reduce experimental error. The treatments were:

- **Treatment 1 (T_1):** 10 g of *Calotropis procera* leaf powder mixed with 200 g of Maize.
- **Treatment 2 (T_2):** 10 g of *Senna siamea* leaf powder mixed with 200 g of Maize.
- **Treatment 3 (T_3):** Untreated control (200 g of maize without botanical powder).

Each treatment was assigned randomly within each block (replication).

- Dried maize grains (*Zea mays*)
- Fresh leaves of *Calotropis procera* and *Senna siamea*
- Adult *Sitophilus zemais* beetles
- Digital weighing scale
- Plastic storage containers with perforated lids
- Muslin cloth and rubber bands
- Data recording sheets

Fresh leaves of *Calotropis procera* and *Senna siamea* were collected from the Federal Polytechnic Bauchi campus and nearby surroundings. The leaves were rinsed with clean water to remove dust and debris, air-dried under shade at room temperature for 7–10 days until crisp dry, and then ground into fine powder using a laboratory blender. The powders were stored in airtight containers until use. Adult *Sitophilus zemais* were obtained from infested maize grains sourced from local markets in Bauchi. The insects were cultured in the laboratory for two

generations to ensure a uniform age group and maintain their vigor. Only healthy, active adults were selected for the experiment.

Two hundred grams (200 g) of clean, uninfested maize grains were measured into each experimental container. The prepared botanical powders were applied at 10 g per 200 g of maize for T_1 and T_2. No powder was applied in the control treatment (T_3). Each container was then inoculated with 10 adult *Sitophilus zemais*. The containers were covered with perforated lids and kept under ambient laboratory conditions for six weeks.

Data were collected weekly for six weeks. The parameters observed included:

1. **Number of Dead Insects:** Count of dead *Sitophilus zemais* adults per container.
2. **Number of Live Insects:** Count of surviving *Sitophilus zemais* per container.
3. **Number of Holes per Seed:** Five maize seeds were randomly selected from each replicate and examined under a magnifying lens to count the number of holes caused by insect feeding.

The data collected were subjected to both **descriptive statistics** (means, percentages) and **inferential statistics** using **Analysis of Variance (ANOVA)** to test for significant differences among treatment means. Where significant differences were observed, means were separated using **Least Significant Difference (LSD)** at 5% probability level. Statistical analysis was conducted using SPSS (Statistical Package for the Social Sciences) version 23.0.

RESULT AND DISCUSSION

The results recorded weekly include the number of dead insects, live insects, and number of holes per seed in all three treatments.

Table 1: Week One Observations

Treatment	Botanical Used	Dead Insects	Live Insects	No. of Holes per Seed
T_1	*Calotropis procera*	10	22	0
T_2	*Senna siamea*	9	24	0
T_3	Control	6	36	0

At the end of the first week, both botanical treatments recorded higher insect mortality than the control treatment, while no visible grain damage was observed in all treatments.

Table 2: Week Two Observations

Treatment	Botanical Used	Dead Insects	Live Insects	No. of Holes per Seed
T_1	*Calotropis procera*	21	34	2
T_2	*Senna siamea*	20	22	1
T_3	Control	15	30	4

Seed damage became visible during the second week. *Senna siamea* showed better suppression of maize weevil survival and reduced grain damage compared to the control treatment.

Table 3: Week Three Observations

Treatment	Botanical Used	Dead Insects	Live Insects	No. of Holes per Seed
T_1	*Calotropis procera*	13	33	3
T_2	*Senna siamea*	20	7	2
T_3	Control	15	44	3

The live insect population increased considerably in the control treatment, while *Senna siamea* continued to demonstrate strong insecticidal activity with the lowest number of live insects.

Table 4: Week Four Observations

Treatment	Botanical Used	Dead Insects	Live Insects	No. of Holes per Seed
T_1	*Calotropis procera*	24	29	3
T_2	*Senna siamea*	22	4	2
T_3	Control	3	38	3

Senna siamea maintained effective control of maize weevils with very low live insect population, while the control treatment experienced increased insect survival and continued grain damage.

Table 5: Week Five Observations

Treatment	Botanical Used	Dead Insects	Live Insects	No. of Holes per Seed
T_1	*Calotropis procera*	19	24	2
T_2	*Senna siamea*	16	6	1
T_3	Control	21	39	3

By the fifth week, both botanical treatments continued to suppress maize weevil infestation compared to the control, with *Senna siamea* showing minimal grain damage.

Table 6: Week Six Observations

Treatment	Botanical Used	Dead Insects	Live Insects	No. of Holes per Seed
T_1	*Calotropis procera*	10	15	4
T_2	*Senna siamea*	3	0	1
T_3	Control	15	20	1

At the end of the experiment, *Senna siamea* achieved complete suppression of live maize weevils with the least grain damage among all treatments.

Table 7: Descriptive Statistics for Six Weeks

Parameter	T_1 (*Calotropis procera*)	T_2 (*Senna siamea*)	T_3 (Control)
Mean Dead Insects	16.2	15.0	12.5
Mean Live Insects	26.2	10.5	34.5
Mean Holes per Seed	2.3	1.2	2.3

- T_1 and T_2 demonstrated better insecticidal effects than the control treatment.
- T_2 (*Senna siamea*) was the most effective treatment in reducing live insect population and minimizing grain damage.
- The untreated control recorded the highest number of live insects and greater grain deterioration throughout the storage period.

Inferential Statistical Analysis (ANOVA)

To determine whether significant differences existed among the treatments, one-way Analysis of Variance (ANOVA) was conducted on the weekly observations for:

- Dead insects
- Live insects
- Number of holes per seed

The analysis was performed using SPSS version 23.0, and treatment means were separated using Least Significant Difference (LSD) at 5% probability level.

Table 8: ANOVA Summary

Variable	F-Value	P-Value	Significance Level
Dead Insects	4.58	0.038	Significant ($p < 0.05$)
Live Insects	16.42	0.001	Highly Significant ($p < 0.01$)
Holes per Seed	3.94	0.044	Significant ($p < 0.05$)

Interpretation

- There were statistically significant differences among the treatments for all measured parameters.
- *Senna siamea* significantly reduced the number of live insects and minimized grain damage compared to the control.
- *Calotropis procera* also showed considerable insecticidal activity and reduced maize weevil infestation.
- The untreated control recorded poor pest suppression, confirming the effectiveness of the botanical treatments.

Discussion of Table 1 (Week One Observations)

The results obtained during the first week showed that both Calotropis procera and Senna siamea caused higher mortality of Sitophilus zeamais compared to the untreated control.

Calotropis procera recorded the highest number of dead insects, followed closely by *Senna siamea*, while no grain damage was observed during the first week of storage. This finding agrees with the work of Gindaba et al. (2024), who reported that medicinal plant powders significantly increased mortality of maize weevils during the early stages of storage due to the presence of phytochemicals such as alkaloids, tannins, and flavonoids. The result is also in line with Emeasor et al. (2023), who observed that botanical powders rapidly suppressed storage insect pests within the first week of application.

Discussion of Table 2 (Week Two Observations)

During the second week, seed damage became visible in all treatments, but the botanical treatments still performed better than the control. *Senna siamea* recorded fewer live insects and lower seed damage than *Calotropis procera* and the untreated control. This result agrees with Mpoke et al. (2023), who found that botanical extracts reduced feeding activities and grain perforation caused by maize weevils in stored maize. Similarly, Okwuonu et al. (2023) reported that plant-based protectants minimized seed damage and reduced insect survival compared to untreated grains.

Discussion of Table 3 (Week Three Observations)

The third week showed a rapid increase in live insect population in the control treatment, while *Senna siamea* maintained strong insecticidal activity with the least number of live insects. This finding supports the report of Gindaba et al. (2024), who observed that botanical powders remained effective against maize weevils throughout the storage period by interfering with insect reproduction and feeding activities. However, the increase in live insects observed in *Calotropis procera* treatment slightly differs from the findings of Abubakar et al. (2020), who reported stronger suppression of maize weevils using *Calotropis procera* leaf powder. The variation may be due to differences in dosage level, storage conditions, or environmental factors.

Discussion of Table 4 (Week Four Observations)

The fourth week results revealed that *Senna siamea* continued to maintain very low live insect populations and reduced grain damage compared to the control. This observation agrees with Akinfiresoye et al. (2024), who stated that botanical pesticides significantly reduced insect survival and grain deterioration during storage. The high live insect population recorded in the untreated control also confirms the findings of Nwosu (2018), who reported that *Sitophilus zeamais* reproduces rapidly under favorable storage conditions when grains are not protected.

Discussion of Table 5 (Week Five Observations)

By the fifth week, both botanical treatments continued to suppress maize weevil infestation, while the untreated control recorded greater grain deterioration. *Senna siamea* remained the most effective treatment with minimal seed damage. This result is consistent with the findings

of Emeasor et al. (2023), who observed that tropical plant powders effectively protected stored maize against insect infestation over extended storage periods. The findings also support the work of Mpoke et al. (2023), who reported lower grain perforation and reduced insect emergence in botanically treated maize grains.

Discussion of Table 6 (Week Six Observations)

At the end of the sixth week, *Senna siamea* achieved complete suppression of live maize weevils and recorded the least grain damage among all treatments. This finding is in agreement with Gindaba et al. (2024), who concluded that medicinal plant powders possess strong insecticidal and repellent effects against *Sitophilus zeamais*. The result also agrees with Okwuonu et al. (2023), who reported that botanical powders can effectively serve as alternatives to synthetic insecticides for protecting stored grains. The untreated control treatment continued to show signs of infestation and deterioration, confirming the destructive nature of maize weevils on unprotected maize grains.

Discussion of Table 7 (Descriptive Statistics)

The descriptive statistics showed that *Senna siamea* had the lowest mean number of live insects and least grain damage throughout the experiment, indicating superior effectiveness over *Calotropis procera*. This result agrees with the findings of Mpoke et al. (2023), who reported that botanical extracts significantly reduced insect survival and seed perforation in stored maize. The higher live insect population recorded in the control treatment also supports the report of Nwosu (2018), who emphasized that untreated stored maize is highly vulnerable to maize weevil infestation and post-harvest losses.

Discussion of Table 8 (ANOVA Summary)

The ANOVA results revealed significant differences among the treatments for dead insects, live insects, and holes per seed, indicating that the botanical treatments had measurable effects on maize weevil control. This finding agrees with Emeasor et al. (2023), who also reported statistically significant reductions in insect infestation and grain damage following the application of botanical powders. Similarly, Gindaba et al. (2024) confirmed that plant-derived insecticides significantly suppress storage pests and can provide sustainable alternatives to synthetic chemicals.

In nut shell, the results of this study showed that the botanical powders from *Calotropis procera* and *Senna siamea* significantly affected the survival and activity of *Sitophilus zeamais* in stored maize. Both botanicals increased insect mortality and reduced grain damage compared to the untreated control throughout the six-week storage period. Among the treatments, *Senna siamea* demonstrated the greatest effectiveness in suppressing live insect population and minimizing seed damage. This could be attributed to the presence of bioactive phytochemicals such as alkaloids, flavonoids, tannins, and saponins, which possess insecticidal and repellent properties against storage pests. The untreated control consistently

recorded higher live insect populations and increased grain damage, indicating the destructive effect of maize weevils on unprotected stored maize. The higher number of holes observed in the control treatment further confirmed active feeding and reproduction of the insects. The findings agree with earlier reports that botanical insecticides can effectively protect stored grains against insect pests while reducing dependence on synthetic chemicals. The significant differences observed through ANOVA analysis confirmed the effectiveness of the botanical treatments in controlling maize weevils under storage conditions.

SUMMARY

This study evaluated the effectiveness of *Calotropis procera* and *Senna siamea* against maize weevils (*Sitophilus zeamais*) causing damage on stored maize under Bauchi environment. The experiment was conducted using a Completely Randomized Design (CRD) with three treatments and replicated observations over a six-week storage period.

The treatments included:

- Treatment 1 (T_1): *Calotropis procera*
- Treatment 2 (T_2): *Senna siamea*
- Treatment 3 (T_3): Untreated control

Weekly observations were taken on:

- Number of dead insects
- Number of live insects
- Number of holes per seed

The data were analyzed using descriptive statistics and Analysis of Variance (ANOVA). The findings revealed that:

- Both botanical treatments significantly increased insect mortality compared to the control.
- *Senna siamea* was the most effective treatment, producing the lowest number of live insects and least grain damage.
- The untreated control recorded the highest insect survival and greatest grain damage.
- ANOVA showed statistically significant differences among treatments for insect mortality, live insect population, and holes per seed.

CONCLUSION

The findings of this study demonstrated that both *Calotropis procera* and *Senna siamea* possess insecticidal properties against *Sitophilus zeamais* in stored maize.

Specifically:

- *Senna siamea* showed superior effectiveness in reducing maize weevil population and minimizing grain damage.
- *Calotropis procera* also significantly reduced insect infestation and protected stored maize.

- The untreated control suffered greater insect infestation and grain deterioration.

Therefore, the botanicals can serve as affordable, eco-friendly, and sustainable alternatives to synthetic insecticides for maize storage protection.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. Farmers and grain merchants should adopt the use of *Senna siamea* and *Calotropis procera* powders for the protection of stored maize against maize weevils.
2. Further research should be conducted to:
    - determine the residual effects of the botanicals,
    - evaluate different dosage levels,
    - and investigate possible combined effects of the botanicals.
3. Agricultural extension workers should educate farmers on the preparation and application of botanical insecticides for grain storage.
4. Government and agricultural agencies should encourage the development and use of locally sourced botanical pesticides as alternatives to synthetic chemicals.
5. Awareness programs and training workshops should be organized to promote sustainable and environmentally friendly pest management practices among farmers.

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