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Posted Date: 8 May 2023

doi: 10.20944/preprints202305.0528.v1

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Comparative Effects of Botanical Powders in Controlling *Sitophilus zeamais* (Maize Weevils) in Stored Maize (*Zea mays* L.)

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Abstract: The objective of this study was to compare the effect of different botanical powders and synthetic chemical in controlling Sitophilus zeamais in stored maize. A laboratory experiment was done to assess three botanicals, Zingiber officinale, Moringa oleifera, Xylopia aethiopica, in controlling the S. zeamais. The results of this study demonstrated the active potentials of these plant products as plant-derived insecticides against maize weevil. The synthetic chemical used showed both higher weevil mortality and higher grain loss than the botanicals ($P< 0.05$). The Botanicals also showed significance difference in the mortality rate ($P < 0.05$) as Z. officinale recorded the highest mortality rate (5.66%) while X. aethiopica recorded the lowest mortality rate (3.66%). The control attained the highest grain damage (7.33%) while amongst the botanicals, the highest was found in Z. officinale (7.33%) and lowest was on M. oliefera (5.33%). The exit holes made by the weevils at the end of the experiment were highest (2.66) in M. oliefera whereas lowest was recorded on X. aethiopica (1.00). Z. officinale, X. aethiopica and M. oleifera were efficacious against S. zeamais instead of synthetic chemical insecticides that have environmental health hazards and they can be used in integrated pest management by farmers and foods merchants. Therefore, since these botanicals have no any adverse effects on the seeds and safe to the environment, they are recommended for future usage in storage grains to control of S. zeamais.

Keywords: Botanicals; *Sitophilus zeamais*; Maize; Storage; Synthetic Pesticide; Pest; Efficacy

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Introduction

One of the main cereal grains grown in large quantities in West Africa, particularly in Nigeria, during the rainy season is maize. After sorghum, millet, and rice, it was the fourth most palatable grain (FAO, 2019). Maize is the top source of calories in the globe for body growth, providing 19.5% of all calories, followed by rice (16.5%) and wheat (15.0%). (FAO, 2019). Huge amounts of maize are produced by peasant farmers each year, frequently producing more than enough to sell in the marketplaces. Due to insufficient storage facilities and insect pest infestation by Sitophilus species, this has led to waste. The maize weevil (*S. zeamais*) is a global pest of maize grains from the farm to the store (Adedire, 2001). *S. zeamais* post-harvest losses have been recognized as being a significant issue for African food security (Abebe et al., 2009; Markham et al., 1999) The maize weevil typically causes postharvest losses in maize grains in Africa that vary between 20 and 30% weight losses during storage for three months on the farm (Boxall, 2002). According to reports, it can harm products both qualitatively and quantitatively, which may be the source of the 20–90% weight loss in grains

 doi:10.20944/preprints202305.0528.v1

observed in untreated stored maize in Africa (Nukenine et al., 2002; Muzemu et al., 2013). In an effort to expand the availability of the grains to rural and urban households, losses of 45–50% in maize grains were noted during storage (Makundi, 2006; Taylor-Davis and Stone, 2007). Maize weevil reduced quality and weight by 60% nutrients in maize during 3-6 months of storage, which have a direct impact on food security in poor nations like Nigeria (Adesina, 2012; Ileke et al., 2016). These damages frequently lead to decreased weight gain and nutritional content, poor seed germination, and eventually low market value (Tefera et al., 2011; Napoleao et al., 2013). The larvae and adult stages of maize weevils, like other pests of the order Coleoptera that attack food storage, are infamous for causing considerable damage (Adedire et al., 2011).

One of the main methods for preventing insect pests from damaging stored grains has been the use of synthetic insecticides (Arthur, 1996). Unfortunately, these insecticides are occasionally scarce, pricey, and/or contaminated in some nations. The temperature, relative humidity, dosage rates, and the predominate insect pest species all have a significant impact on the effectiveness of these pesticides (Arthur, 1996). However, these pesticides' efficacy is constrained by their high cost of acquisition, accumulation of toxic residue in foods, development of pest resistance, eradication of natural enemies, and negative effects on non-targeted creatures (Oni and Ileke, 2008). Focusing study on the effectiveness of plant materials, such as plant powders, plant extracts, and plant oils to determine their insecticidal capabilities is a contemporary trend intended to alleviate the issues connected with the usage of synthetic chemical pesticide (Adedire et al., 2011; Ileke et al., 2016). This is so because research has shown that employing natural remedies has much less of an impact than using synthetic chemical insecticides, which can cause serious issues for plants. Additionally, farmers find it more convenient to employ botanical treatments in the form of powders and extracts to control stored product weevils and beetles since they are simple for small-scale farmers to apply and the produce continues to be attractive to consumers even after use (Ojo and Ogunleye, 2013). Natural plant products have been shown to be affordable, safe for humans, and ecologically tolerant to control approaches to lessen pest infestations of stored goods, especially in the tropics (Lale, 1992; Adedire and Ajayi, 1996). Many botanicals that are employed as crop protectors in the control have been found to be safe for human consumption (Omotoso, 2014). Scent leaves *(Ocimum gratissimum*), garlic (*Allium sativum*), and neem (*Azadirachta indica*) are examples of plants (Ileke and Oni, 2011; Karunakaran and Arulnandhy, 2018).

This research aims to use natural methods to manage *S. zeamais*. There is no scientific information on the sections to use in suppressing this specific maize weevil, despite the fact that different portions of the botanicals to be employed have been found to have a variety of effects on different stored plants. In this work, the bio-insecticidal properties of powdered *Zingiber officinale* (Ginger), *Moringa olifera* (Moringa), and *Xylopia aethiopica* (Negro Pepper) are confirmed as an environmentally friendly defense against adult maize weevil, *S. zeamais*, in stored maize.

Materials and Methods

Experimental Site

The study was carried out in the Pest control laboratory of the Federal College Of Animal Health And Production Technology Vom at the Chaha Campus.

Experimental Materials

The following materials were used for this study; *Zea mays* (maize seeds), *Zingiber officinale* (ginger), *Moringa olifera* (moringa), *Xylopia aethiopica* (negro pepper), Aluminum phosphate, Selo tape, Storage containers (jars), Mucilage cloth, Marker, Rubber bands, Hand lens, Thermometer, Weighing scale, Scissors.

Experimental Procedure

Collection and Source of Maize grains

A local market was used to obtain an open-pollinated maize grain. The grain was sieved to remove any dead seed, soiled, or broken pieces as well as to remove any potential pre-existing *S. zeamais* inoculum and eggs from the grain.

Weevil selection

S. zeamais adult maize weevils were obtained from a nearby farmer. At Bukuru, Jos Plateau state, Nigeria, a local market provided 600g of maize grains, which were then inoculated with fifty pairs of the weevils. The weevil colony was kept in an insectarium with a constant temperature and relative humidity of 28°C and 75°F. The FCAH&PT, Vom pest control laboratory identified and sexed *S. zeamais.* The length of the rostrum was then used to classify adults as male or female (the female has a comparatively longer rostrum

Collection and preparation of plant powders

The plant parts of *Zingiber officinale, Moringa oliefera*, and *Xylopia aethiopica*, were sourced from local market in Jos Plateau state, Nigeria. These leaves were first of all air dried naturally in the laboratory. The dried leaves were later pulverized separately into fine powder with the aid of a mechanical grinding machine. The fine powders were allowed to pass through a nylon mesh of 1 mm2 dimension. The powders were then packed into an air tight container and put in a refrigerator at 4 °C to retain its good quality before application.

200g of maize grains was poured into a storage container where 10 males and 10 females of Adult maize weevil (*S. zeamais)* were added to the grains. Then quantities (5% of 200g) of each botanical was measured and thoroughly mixed with the grains in containers assigned for their treatment. The synthetic pesticide (Aluminum phosphate) was used at a label rate of 0.20g/200g of maize. All parameters were measured at interval within a space of 3 weeks.

Experimental Design

A 3 × 3 factorial experiment laid in a Complete Randomized Design (CRD) which was replicated five times (Ginger, Moringa, Negro pepper, Control and Synthetic chemical) was used in the arrangement of the storage

Data Collection

Data were collected by checking for the following parameters; Efficacy of different treatments on weevil mortality, Efficacy of the botanical powders and synthetic chemical on the emergence of *S. zeamais*, grain damage, weight of damaged grain

Statistical Analysis

Data were subjected to analysis of variance (ANOVA) using the statistical package SPSS 25.0 software (SPSS, 2017). Means were separated using Least Significant Difference (LSD).

Result and Discussion

Table 2 shows a significant difference ($P < 0.05$) in the efficacy of the different treatments on *Sitophilus zeamais* on the weevil mortality in all the weeks. In the first week after treatment, every weevil found in maize seed treated with aluminum phosphate (0.2g) perished and was unable to create offspring. The highest and lowest mortalities for the botanicals at week 1 were found in *Xylopia aethiopica* (4.66%) and *Zinigiber officinale* (4.33%), respectively. The synthetic chemical recorded 20% mortalities at 1 week after weevil inoculation and was very efficient in suppressing adult *S. zeamais*, which is consistent with Asawalam and Emosairue (2006) who reported 100% mortality to *S. zeamais*

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when treated with synthetic chemical in stored maize. The mortality rate for the control group was 5.33%. The weevil mortality rates rose starting in week 1, attained their peak at week 2 after weevil inoculation, and then gradually decreased until week 3. This implies that the active ingredient persistence was lower after 3 weeks of treatments, which is in conformity with Asmare's report from 2002 that the killing effect of botanicals was not as acute as chemical insecticides in the first week after treatment.

Table 1. List of Botanicals tested for the effectiveness against *Sitophilus zeamais* in some stored Grains.

Scientific Name of Plants	Common Name	Family	Parts Used
Zingiber officinale	Ginger	Zingiberaceae	Rhizome
Moringa oleifera	Moringa	Moringaceae	Leaves
Xylopia aethiopica	Negro pepper	Annonaceae	Bark and seed

Table 2. Efficacy of the different treatments on the Weevil Mortality.

		Weeks	
Treatment	**One**	**Two**	**Three**
Zingiber officinale	4.33^{b}	6.33 ^{a}	5.66 ^{a}
Moringa oliefera	3.66 ^{b}	5.33 ^{a}	2.33 ^{b}
Xylopia aethiopica	4.66 ^{b}	5.33 ^{a}	3.66 ^{b}
Aluminium phosphate	20.00 ^{a}	0.00 ^{c}	0.00 ^{c}
Control (Untreated)	5.33 ^{b}	2.33 ^{b}	3.66 ^{b}
P value	0.000	0.000	0.000

Legend: Means that do not share a letter within the same column are significantly different from each other at ($P \leq 0.05$).

At week 2, *Z. officinale* (ginger) had the highest mortality rate (6.33%), whereas *M. olifera* (moringa) and *X. aethiopica* (negro pepper) had the lowest mortality rates (5.33%). The control (untreated grain) had a mortality rate of 2.33%, whereas the synthesized chemical recorded the lowest mortality rate of 0.00%. Even though there was a decrease in the death rate from week 2, the Botanicals also demonstrated a significant difference in the mortality rate (P 0.05) at week 3. *Z. officinale* recorded the greatest mortality rate (5.66%), while *X. aethiopica* recorded the lowest mortality rate (3.66%). While the control likewise recorded 3.66% mortality rates, synthetic chemicals exhibited 0% mortality rate.

The impact of various plant materials on insects may be influenced by a number of variables, including chemical composition and species sensitivity (Aktar and Isman, 2004). It's possible that disruptions or genetic flaws are to blame for the weevil mortality in the untreated grain (Gadzirayi et al., 2006). The highest feeding rates are provided by untreated grain because it provides weevils with a free environment where their ability to develop is unrestricted.

According to Table 3, every botanical employed to manage weevils had a significant impact on grain damage over control (P 0.05). At week 1, *Zingiber officinale* had the highest percentage of grain damage (7.33%) and *Moringa oliefera* had the lowest proportion (5.33%), compared to the synthetic chemical's 3.66% and the untreated (control) samples' 5.33%. A similar report on *M. oleifera's* impact on *Callosobruchus maculatus* was published by Mbailao et al. in 2006. The untreated grain (Control) saw the maximum grain damage at weeks two and three (7.33% and 5.00%, respectively). Moringa oliefera was the botanical with the highest percentage grain damage at weeks 2 and 3 (6.33% and 4.66%), respectively, while *Xylopia aethiopica* had the lowest percentage grain damage at week 2 (5.66%). The lowest grain damage for week 3 was 2.66%, and it was achieved by *Zingiber officinale* and *Xylopia aethiopica.*

Table 3. Efficacy of the different treatments on the Grain Damaged.

	Weeks		
Treatment	**One**	**Two**	**Three**
Zingiber officinale	7.33 a	5.66 a	2.66 b
Moringa oliefera	5.33 ab	6.33 a	4.66 a
Xylopia aethiopica	6.00 ab	5.66 a	2.66 b
Aluminium Sulphate	3.66 b	0.00 b	0.00 c
Control (Untreated)	3.66 b	7.33 a	5.00 a
P value	0.003	0.000	0.000

Legend: Means that do not share a letter within the same column are significantly different from each other at ($P \leq 0.05$).

Table 4 displays how various botanicals affect the quantity of exit holes. There was no significant difference in the number of exit holes between the botanicals at week 1 ($P > 0.05$). In terms of exit holes, Control had the most (2.00), while Ginger was the botanical with the greatest number (2.00) at both week 1 and week 2, respectively. At weeks 2 and 3, the synthetic substance didn't exhibit any exit holes (0.00). The maximum number of exit holes the weevils formed at the conclusion of the trial (week 3) were found in Moringa, while the lowest number was found on seeds treated with negro pepper (1.00). At the conclusion of the experiment, the untreated (control) group recorded 1.66.

Table 4. Effects of different treatments on the Number of Exit Holes on Grains.

	Weeks		
Treatment	**One**	**Two**	**Three**
Zingiber officinale	2.00 a	2.00 a	1.66 a
Moringa oliefera	1.66 a	1.66 a	2.66 a
Xylopia aethiopica	1.66 a	1.33 a	1.00 a
Aluminium Sulphate	1.66 a	0.00 b	0.00 a
Control	2.00 a	2.00 a	1.66 a
P value	0.737	0.000	0.078

Legend: Means that do not share a letter within the same column are significantly different from each other at ($P \leq 0.05$).

Table 5 shows that there were significant ($P < 0.05$) differences in the number of weevil population (newly emerged weevils) all through the experiment. As compared to other treatments, the effect of *Xylopia aethiopica* treated maize seeds had a significant impact on the weevil population (P 0.05), as it recorded the greatest weevil population (1.66) compared to other botanicals. At the end of the experiment, *Zingiber officinale*-treated seeds had the fewest weevils (0.33), while untreated seeds had the most weevils (2.33). (control).

Table 5. Effects of treatments on Newly Emerged Weevils.

	Weeks		
Treatment	**One**	**Two**	**Three**
Zingiber officinale	1.33 ab	1.33 ab	0.33 b
Moringa oliefera	1.33 ab	1.33 ab	1.33 ab
Xylopia aethiopica	1.66 a	1.00 bc	0.66 b
Aluminium Sulphate	0.00 b	0.00 c	0.00 b
Control (Untreated)	1.66 a	2.33 a	2.33 a
P value	0.014	0.001	0.002

Legend: Means that do not share a letter within the same column are significantly different from each other at ($P \leq 0.05$).

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Table 6. Effect of the different treatments on the Weight loss of grains after weeks.

Parameter	Ginger	Moringa	Negro Pepper	Aluminium Phosphate	Control (Untreated)
Weight Loss of Grains	4.52 [b]	3.58 [d]	4.13 [c]	5.24 [a]	3.21 [e]

Legend: Means that share a letter across the row are significantly different from each other at (P ≤ 0.05). A significant difference in the weight loss of grains following the experiment is shown in Table 6. When compared to controls, grains treated with botanicals showed a substantial weight loss (P 0.05). The weight loss in treated maize grains with *Moringa oleifera* was the least (3.58), while the greatest loss was seen in *Zingiber officinale* (4.52). In terms of weight reduction, the synthethic chemical (5.24) outperformed the control (3.21) and botanicals. In this study, all of the botanicals utilized for their insecticidal characteristics greatly slowed the weight loss *S. zeamais* produced. Due to excessive insect mortality, plant powders may be able to totally prevent weight loss. According to Alabi and Adewole, it may possibly be because the insects were unable to deposit their eggs on the grains that had been treated, which would have averted seed damage and weight loss by allowing the larvae to feed (2017).

Conclusion and Recommendation

Conclusion

In comparison to synthetic chemical pesticides that pose risks to the environment and users' health, *Zingiber officinale, Xylopia aethiopica, and Moringa oleifera* powder extracts have been proven to have strong insecticidal efficacy against maize weevil.

Recommendation

Since the plant is environmentally friendly, easily accessible, and used among rural peoples for its ethno medical significance, it should be encouraged that poor resource farmers and food merchants use *Zingiber officinale, Xylopia aethiopica,* and *Moringa oleifera* powders as bio-insecticides in the control of maize weevil in stored maize seeds. To establish the effectiveness of these medicinal herbs, which will lessen the bulk of the powders when used for storage management of agricultural pest in bags or storage bins, more research is required to assess the effectiveness of these medicinal herbs.

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