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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

Sitophilus zeamais (maize weevil) is a field and storage pest of maize of economic importance in several parts of Africa. Controlling of the pest by use of synthetic pesticides is raising serious concern on the environmental safety and consumer health hazards. The objective of this study was to compare the effect of different botanical powders and synthetic chemical in controlling Sitophilus zeamaiz in stored maize. The experiment was laid in a Completely Randomized Design (CRD) with an application rate of 10g/ 200g of the botanicals replicated three times was used in the assessment. A laboratory experiment was done to assess three botanicals, Zingiber officinale, Moringa oleifera, Xylopia aethiopica, in controlling the S. zeamais. A synthetic chemical (aluminum phosphate) 0.20g/200g was used as a control pesticide to compare the efficacy of the botanicals on the maize weevil. The parameters and data collected in the experiment are; percentage of weevil mortality, Grain damaged, Number of Exit holes, newly emerged weevil, percentage of weight damaged. All data generated were statistically analyzed. The results of this study demonstrated that 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). The lowest weight loss was found in M. oleifera (3.58) and highest loss was observed in Z. officinale (4.52). The synthethic chemical also recorded the highest weight loss (5.24) compared to control (3.21). 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

INTRODUCTION

Maize is one of the major cereal grains cultivated in abundance during the raining season in West Africa most especially in Nigeria. It ranked fourth most edible grain after sorghum, millet and rice (FAO, 2019). Maize accounted for 19.5% calorie being the world's highest supplier of calorie for body growth, followed by rice (16.5%) and wheat which accounted for 15.0% (FAO, 2019). Peasant farmers produce huge tons of maize annually which is usually more than enough for sale in the markets. This has resulted into wastage due to inadequate storage structures and insect pest attack such as *Sitophilus* species. The maize weevil (*S. zeamais*) is a field-to-store pest of maize grains in the world (Adedire, 2001). Post-harvest losses to *S. zeamais* have been acknowledged as an increasingly important problem to food security in Africa (Abebe *et al*., 2009; Markham *et al*., 1999) Generally, postharvest losses in maize grains due to maize weevil range between 20 and 30% weight losses during storage for three months on farm in Africa (Boxall, 2002). It has been reported to cause both qualitative and quantitative damages to stored products which could account for grain weight loss of about 20–90% for untreated stored maize in Africa (Nukenine *et al*., 2002; Muzemu *et al*., 2013). Losses of 45–50% in maize grains were recorded during storage in an attempt to increase the supply of the grains in rural and urban household (Makundi, 2006; Taylor-Davis and Stone, 2007). Maize weevil caused 60% weight losses and quality in terms of nutritional values in maize within 3–6 months in storage which directly affect food security in developing countries such as Nigeria (Adesina, 2012; Ileke *et al*., 2016). Often times, these damages result to reduced nutritional value and weight loss, low seed germination and ultimately low market value (Tefera *et al*., 2011; Napoleao *et al*., 2013). The larvae and the adult stages of maize weevils are notorious for causing serious damages just like other food storage insect pests that belong to the order Coleoptera (Adedire *et al*., 2011).

Synthetic pesticides have been one of the major means of protecting stored grain against insect pests (Arthur, 1996). However, in some countries such pesticides are sometimes unavailable, expensive and/or adulterated. The efficacy of these insecticides is also greatly influenced by environmental conditions, particularly temperature and relative humidity (Arthur, 1996) dosage rates and the dominant insect pest species. Climate change points to a warming trend and highly variable rainfall patterns (Sharma, & Prabhakar, (2014)., presenting new problems to postharvest grain handling through possible altered pest physiology, spectrum, behavior and pesticide efficacy. But the effectiveness of these insecticides is limited, due to high cost of procurement of the chemicals, toxic residue buildup in foods, and development of resistance by the pest, destruction of natural enemies and also harmful to non-targeted organisms (Oni and Ileke, 2008). A modern trend aimed at alleviating the problems associated with the use of synthetic chemical insecticide is focusing research in the area of the efficacy of plant materials, such as plant powders, plant extracts and plant oils to ascertain their insecticidal properties (Adedire *et al.,* 2011; Ileke *et al*., 2016). This is because findings have shown that the use of botanicals have little or no effects as compared to the problems pose to the plant using synthetic chemical insecticides. Also, the use of botanical products in form of powders and extracts to control stored product weevils and beetles is more convenient by farmers, the powders and extracts are easy to apply by peasant farmers and the produces remain fresh, clean and attractive to buyers after the treatment (Ojo and Ogunleye, 2013). Natural plant produces have been found to be cheap, humanly safe and ecologically tolerant to control measures of reducing the infestations of stored product pests especially in the tropics (Lale, 1992; Adedire and Ajayi, 1996). It has been discovered that many of the botanicals used as crop protectants in the control are safe for human consumption (Omotoso, 2014). Plants such as neem (*Azadirachta indica),* garlic (*Allium sativum*), scent leaves (*Ocimum gratissimum*) (Ileke and Oni, 2011; Karunakaran and Arulnandhy, 2018).

This project work wants to embark on natural means to control *S. zeamais.* Although different parts of the botanicals to be used have been reported to have several effects on different stored plants, there is no scientific report on the parts to be used in controlling this particular maize weevil. This study is an attempt to confirm the bio-insecticidal activities of *Zingiber officinale* (Ginger), *Moringa olifera* (Moringa), and *Xylopia aethiopica* (Negro pepper) powders as an ecofriendly protectants 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

An open pollinated maize grain, sourced from a local market was used. The grain was sieved to remove dead seed, dirty and broken particles and also to sieve out any prior sources of the *S. zeamais* inoculum and eggs which might be already pre-existing in the grain.

Weevil selection

Adults maize weevil, *S. zeamais* were sourced and gotten from a local farmer, where. Fifty pairs of the weevils were introduced into 2kg storage container containing 600g of maize grains obtained from a local market in Bukuru Jos Plateau state, Nigeria. The weevil colony was maintained under a constant insectarium condition of 28±2 ◦C and 75 ± 5% relative humidity.The identification and sexing of *S. zeamais* were carried out in the pest control laboratory of the FCAH&PT, Vom. Then, adults were sexed according to the length of the rostrum (the female has a comparatively longer rostrum than the male).

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).

RESULTS AND DISCUSSION

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 ($P \leq 0.05$)

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. All weevils of maize seed treated with Aluminium phosphate (0.2g) died within week 1 of treatment; and couldn't produce their progenies. For the botanicals at week 1, the Highest and lowest mortalities were recorded on *Xylopia aethiopica* (4.66%) and *Zinigiber officinale* (4.33%) respectively. The synthetic chemical recorded 20% mortalities at 1 week after weevil inoculation and it was very effective in controlling adult *S. zeamais* which is in conformity with Asawalam *et al.,* (2006) who reported 100% mortality to *S. zeamais* when treated with synthetic chemical in stored maize. The control recorded 5.33% mortality rate. The weevil mortality rates increased from week 1, it was maximum at week 2 after weevil inoculation and thereafter decreased gradually until week 3 in all the botanicals which means that the active ingredient persistence was lower after 3 weeks of treatments which is in agreement to report by Asmare (2002), that the killing effect of botanicals was not acute as chemical insecticides in the first week after treatment. At week 2, the highest mortality rate (6.33%) was obtained in *Z. officinale* (Ginger) while the lowest mortality rate (5.33%) was obtained in both *M.olifera* (Moringa) and *X. aethiopica* (Negro Pepper) respectively. The synthetic chemical recorded 0.00% which was the lowest and the control (untreated grain) recorded 2.33% mortality rate. The Botanicals also showed significance difference in the mortality rate ($P < 0.05$) at week 3 as *Z. officinale* recorded the highest mortality rate (5.66%) while *X. aethiopica* recorded the lowest mortality rate (3.66%) even though there was a decrease in the mortality rate from week 2. Synthetic chemical showed no mortality rate while the control also recorded 3.66% mortality rates.

The effects of different plant materials on insects may depend on several factors such as chemical composition several factors such as chemical composition and species susceptibility (Aktar and Isman, 2004). The weevil mortality in the untreated grain might be due to disturbances or genetic weaknesses (Gadzirayi *et al.,* 2006). The untreated grain offers free environment where weevils suffer no developmental limitations hence the highest feeding rates.

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

TREATMENTS	WEEKS 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 ≤ 0.05)

Table 3 shows that all the botanicals used for the weevil management had a significant difference (P < 0.05) on grain damage over control. At week 1, the highest percentage grain damage was found in *Zingiber officinale* (7.33%) and lowest was on *Moringa oliefera* (5.33%) while the synthetic chemical and the untreated (control) had 3.66% respectively. Mbailao *et al.,* (2006) made similar report on the effect of *M. oleifera* on *Callosobruchus maculatus*. At week 2 and 3, the untreated grain (Control) attained the highest grain damage (7.33% and 5.00%) respectively. Among the botanicals at week 2 and 3, the highest percentage grain damage was recorded in *Moringa oliefera* (6.33% and 4.66%) respectively, while the lowest (5.66%) at week 2 was recorded in *Xylopia aethiopica.* For week 3, *Xylopia aethiopica* and *Zingiber officinale* attained the lowest grain damage of 2.66%.

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

TREATMENTS	WEEKS ONE	TWO	THREE
Zingiber officinale	2.00[a]	2.00[a]	1.66[a]
Moringa oleifera	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 ≤ 0.05)

Table 4 shows the effect of different botanicals on the number of exit holes. At week 1, there was no significant difference (P < 0.05) in the number of exit holes between the botanicals. Control obtained the highest number (2.00) of exit holes while amongst the botanicals; Ginger obtained the highest (2.00) both at week I and 2 respectively. The synthetic chemical showed no exit holes at week 2 and 3 respectively (0.00). The exit holes made by the weevils at the end of the experiment (week 3) were highest (2.66) in Moringa whereas lowest was recorded on Negro pepper treated seeds (1.00). The untreated (control) recorded 1.66 at the end of the experiment

Table 5: Effects of treatments on Newly Emerged Weevils

	WEEKS		
TREATMENTS	**ONE**	**TWO**	**THREE**
Zingiber officinale	1.33^{ab}	1.33^{ab}	0.33^{b}
Moringa oleifera	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 ($P \leq 0.05$)

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

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 ($P\leq 0.05$)

Table 6 shows a significant difference in the weight loss of grains after experiment. A significant weight loss has been observed in botanicals treated grains as compared to control ($P < 0.05$). The lowest weight loss was found in *Moringa oleifera* treated maize grains (3.58) and highest loss was observed in *Zingiber officinale* (4.52). The synthethic chemical also recorded the highest weight loss (5.24) compared to control (3.21) and the botanicals. All the botanicals for insecticidal properties in this research work significantly reduced weight loss caused by *S. zeamais*. The ability of the plant powders to completely prevent weight loss could be due to high insect mortality. It could also be due to the fact that the insects could not lay eggs on the treated grains which could have led to larval feeding and consequently prevented seed damage and weight loss as suggested by Alabi and Adewole (2017).

CONCLUSION AND RECOMMENDATION

Conclusion

Zingiber officinale, *Xylopia aethiopica*, and *Moringa oleifera* powders extracts are found to have potent insecticidal activity toward maize weevil instead of synthetic chemical insecticides that causes environmental health hazards and lethal dose to the users.

Recommendation

The use of *Zingiber officinale*, *Xylopia aethiopica*, and *Moringa oleifera* powders as bio-insecticides in the control of maize weevil in stored maize seeds among poor resource farmers and food merchants should be advocated since the plant is ecofriendly and readily available and used among rural peoples for its ethno medical importance. Further studies are needed to determine the efficacy of these medicinal plants, which will reduce the bulkiness of the powders when used for storage control of crop pest in bags or in storage bins.

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