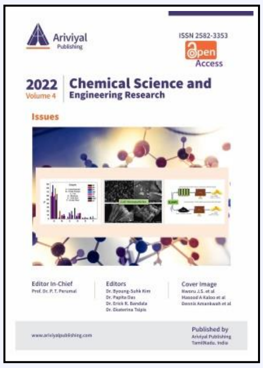
Chemical Science & Engineering Research

Ariviyal Publishing

Research Article

DOI: 10.36686/Ariviyal.CSER.2022.04.10.058

*Chem. Sci. Eng. Res., 2022, 4(10), 58-61.*



# The Effect of Integrating Maize Accessions with Plant Powders on *Sitophilus Zeamais* Motschulsky (Coleoptera: Curculionidae) in Stored Maize

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ISSN: 2582-3353

Crossref

**Publication details**

Received: 17th June 2022

Revised: 11th August 2022

Accepted: 11th August 2022

Published: 22nd August 2022

**Abstract:** Maize infestation by pests during storage which often leads to weight losses is one of the challenges in maize storage. The consumption of pest-infested maize grain is very unhealthy, as these grains are prone to contamination by mycotoxins. This study assessed the effect of integrating maize accessions with plant powders on *Sitophilus zeamais* in stored maize. A comparative study of three maize accessions TZM 124,136 and 125 were integrated with three plant powders namely *Piper guineense, Annona squamosa* and *Vernonia amygdalina* on cultured maize weevil, *Sitophilus zeamais* Motschulsky through laboratory assays experiment in a completely randomized design with four replicates. The effect and susceptibility of *Sitophilus zeamais* with maize accessions were compared using Student Newman Keul at p<0.05. Maize accession TZM 136 integrated with *P. guineense* and TZM 125 integrated with *A. squamosa* recorded 100% mortality at 7 days without egg laid and seed damage. The integration of *P. guineense* with TZM-136,124,125 recorded no seed damage. No adult emerged in all the three maize accessions treated with *Annona squamosa* for the F1 generation. All the maize accessions integrated with all the three plant powders recorded a significantly higher percentage of seed germinability compared to the control. The study concluded that maize accessions TZM 124,136,125 with *Piper guineense, Annona squamosal,* and *Vernonia amygdalina* is a good management strategy and thus recommended for the control of *Sitophilus zeamais*.

**Keywords:** Maize; *Sitophilus zeamais*; Storage; Infestation; Management

## 1. Introduction

Maize is one of the most produced cereal food and it is use as mainly for human consumption and to make feed for animals (Siwale et al., 2009).[1] Maize is very nutritious with nutritional content of about 70-72% digestible carbohydrate, 4-4.5% fats and oils and 9.5-11% proteins.[1-30] It can be stored for a long time however, to maintain quality of long term storage seed is a problem in many parts of the world. Total seed stored of about 8-10% in warehouses or in silos is lost yearly because of inappropriate storage conditions (Boxall, 2001).[2] The grain quality can degrade showing cracking of seeds due to over drying, weight loss due to respiration, rodents and insects' infestation and damage, and contamination with mycotoxins caused by moulds (Boxall, 2002).[3] Maize is exposed to insect pest attack before harvest and in storage. Some of these pests include *Tribolium castaneum H., Sitophilus zeamais Motsch., Prostephanus truncatus H., Sitophilus oryzae L.*, and *Ephestia cautella W*. (Muyinza, 2008). Most of the pests of stored maize are coleopterans, Sitophilus and Tribolium species are the most destructive tropical species for maize (Belloa et al., 2000).[4]

The maize weevil, *Sitophilus zeamais* (Motsch.) is a primary field-to-store pest of maize in tropical and subtropical regions. It is a small weevil measuring 2.5 - 4.5 mm in length and can live up to 12 months, depending on environmental conditions (Longstaff, 1981).[5]

Stored-product insects and mites cause considerable post-harvest losses, estimated to range from 9% in developed countries to 20% or more in developing countries (Saeed, 2017).[6] Pest infestations decrease the value of the commodity by contaminating it with insect wastes, faeces, webbing, and metabolic by-products (Lord et al., 2001).[7]

Maize weevils, especially *Sitophilus zeamais* infest maize while the crop is still in the field (Pendleton et al., 2005; Asawalam & Hassanali, 2006;[8] Siwale et al., 2009)[1] it destroys the crop during storage (Pingali, 2001).[9] Despite the increased understanding of the inheritance of weevil resistance and of the resistance mechanisms in the maize grains, there has been very little application of this knowledge in maize storage techniques (Dhliwayo & Pixley, 2002).[10] This study was aimed at determining the effect of integrating maize accessions with Plant Powders on *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae) in stored maize.

**Table 1.** Efficacy of integrating three plant powders with three maize accessions against *S. zeamais* measured in terms of adult mortality at seven days post treatment

| | Maize accessions | | |
|---|---|---|---|
| **Plant powders** | **TZM-124** | **TZM-136** | **TZM-125** |
| *Piper guineense* | 75.00a | 100.00a | 85.00a |
| *Vernonia amygdalina* | 75.00a | 60.00a | 80.00a |
| *Annona squamosa* | 75.00a | 90.00a | 100.00a |
| Control | 0.00b | 0.00b | 0.00b |

Means followed by the same letter within a column are not significantly different at the 5% level of probability (Student – Newman-Keuls (SNK)).

**Table 2.** Efficacy of integrating three most active plant powders with three maize accessions against *S. zeamais* measured adult emergence at 36-42 days

| | Maize accessions | | | | | |
|---|---|---|---|---|---|---|
| **Plant powders** | **F1 Generation** | | | **F2 Generation** | | |
| | **TZM-124** | **TZM-136** | **TZM-125** | **TZM-124** | **TZM-136** | **TZM-125** |
| *Piper guineense* | 0.25a | 0.00a | 1.50a | 0.00a | 0.00a | 0.25a |
| *Vernonia amygdalina* | 1.00a | 0.00a | 0.00a | 0.00a | 0.00a | 0.10a |
| *Annona squamosa* | 0.00a | 0.00a | 0.00a | 0.00a | 0.00a | 0.00a |
| Control | 16.00b | 28.00b | 8.00b | 12.50b | 25.50b | 10.25b |

Means followed by the same letter within a column are not significantly different at the 5% level of probability (Student – Newman-Keuls (SNK)).

## 2. Materials and Methods

### *2.1. Study Area*

The laboratory experiment was set up at the Department of Crop Protection, Federal University of Agriculture Abeokuta with a temperature of 26.6$^{o}$C and Relative humidity of 89%; located at Latitude 7$^{o}$ 901N and Longitude 30$^{o}$ 211 E.

### *2.2. Sampling Techniques and Data collection*

The maize accessions TZM 124, TZM 136 and TZM 125 were obtained from International Institute of Tropical Agriculture (IITA) while the botanicals *Piper guineense* (seed), *Annona squamosa* (leaf) and *Vernonia amygdalina* (leaf) were obtained from Abeokuta, Ogun State and identified at the Department of Forestry and Wildlife, Federal University of Agriculture, Abeokuta. Similarly, *Sitophilus zeamais* were obtained from naturally infested maize seeds from maize sellers at Kuto market Abeokuta, Ogun state, Nigeria and identified based on their morphological appearance according to Halstead, 1963.

### *2.3. Laboratory Analysis and Quality Assurance*

The botanicals; *Piper guineense*, *Annona squamosa* and *Vernonia amygdalina* were air-dried for two weeks and pulverised into fine powder in a Marlex electroline 750 watts milling machine. The powder of each was kept in air tight container to retain its potency and avoid loss of odour. One kilogram (1 kg) of SWAN-1 maize seeds were put in each of 20 Kilner jars in which five pairs of adult *Sitophilus zeamais* were introduced into the Kilner jars containing the maize seeds to culture the insect. The Kilner jars were covered with fine mesh cloth fastened with rubber bands to prevent contamination and escape of the insects.

**Table 3.** Efficacy of integrating three plant powders with three maize accessions against *S. zeamais* measured in terms of percentage seed germinability at forty-two days

| | Maize accessions | | |
|---|---|---|---|
| **Plant powders** | **TZM-124** | **TZM-136** | **TZM-125** |
| *Piper guineense* | 85.00a | 70.00a | 80.00a |
| *Vernonia amygdalina* | 65.00a | 55.00a | 55.00a |
| *Annona squamosa* | 70.00a | 70.00a | 75.00a |
| Control | 5.00b | 12.50b | 10.00b |

Means followed by the same letter within a column are not significantly different at the 5% level of probability (Student – Newman-Keuls (SNK)).

The introduced insects were allowed to mate and oviposit for 7 days after which the parent stock was sieved out while the maize seeds containing eggs were left undisturbed until the new adults emerged.

The newly emerged adults of *Sitophilus zeamais* were sustained by replacing the devoured seeds of maize continuously with fresh maize that were not infested and used for the various experiments according to (Adedire and Lajide, 1999). Conversely, 10 g of three maize accessions (TZM-124, TZM-136 and TZM-125) were combined with three plant powders and were infested with five adult *Sitophilus zeamais* in each Kilner jar.

The seeds were treated with 2.5g powders of each plant powders and the untreated control was infested with only adult *Sitophilus zeamais* without plant powders, all treatments were replicated four times. At the end of 28 days, the mortality was recorded and adult emergence was recorded at 36 to 42 days. The germinability of the treated seeds was tested in Petri dishes lined with moist filter paper.

### *2.4. Statistical analysis*

The Analysis of Variance (ANOVA) for all the measured parameters was done using Student Newman Keuls (SNK) and the Significant means were at $P<0.05$.

## 3. Results

Integration of powders of *P. guineense* with TZM-136 and *A. squamosa* with TZM-125 gave 100% weevil mortality at 7 days post treatment (Table 1). Accession TZM-125 in combination with the three plant powders gave a higher mortality compared to other combinations with significant effect ($p < 0.05$). The control recorded no mortality in all the accessions. According to Table 2 no adult emerged in all the three maize accessions treated with *A. squamosa* for F1 and F2 generation. Significantly lower adult emergence was observed in maize accessions treated with *P. guineense* and *V. amygdalina* compared to the control.

Maize accession TZM-124 integrated with *P. guineense* recorded the highest seed germinability. All the maize accessions integrated with all the three plant powders recorded significantly higher percentage seed germinability compared to the control (Table 3). Similarly, higher mortality was recorded in the control after 28 days post treatment compared to the treated varieties (Table 4). TZM-125 (integrated with *V. amygdalina* and *A. squamosa*) as well as TZM-136 (integrated with *P. guineense* and *V. amygdalina*) recorded no mortality.

**Table 4.** Efficacy of integrating three plant powders with three maize accessions against *S. zeamais* measured in terms of adult mortality at twenty-eight days post treatment

| | Maize accessions | | |
|---|---|---|---|
| **Plant powders** | **TZM-124** | **TZM-136** | **TZM-125** |
| *Piper guineense* | 6.50a | 0.00a | 5.00a |
| *Vernonia amygdalina* | 8.50a | 0.00a | 0.00a |
| *Annona squamosa* | 0.00a | 2.00a | 0.00a |
| Control | 35.50b | 25.00b | 20.00b |

Means followed by the same letter within a column are not significantly different at the 5% level of probability (Student – Newman-Keuls (SNK)).

**Table 5.** Efficacy of integrating three plant powders with three maize accessions against *S. zeamais* measured in terms of percentage seed damage at forty-two days

| | Maize accessions | | |
|---|---|---|---|
| **Plant powders** | **TZM-124** | **TZM-136** | **TZM-125** |
| *Piper guineense* | 0.00a | 0.00a | 0.00a |
| *Vernonia amygdalina* | 2.50a | 0.00a | 0.00a |
| *Annona squamosa* | 0.00a | 0.00a | 1.25a |
| Control | 12.00b | 18.50b | 22.50c |

Means followed by the same letter within a column are not significantly different at the 5% level of probability (Student – Newman-Keuls (SNK)).

All the three accessions integrated with *P. guineense* recorded no seed damage. All the maize accessions irrespective of the integrated plant powders recorded lower seed damage compared to the control (Table 5). There was a significant reduction in the number of eggs laid in all the maize accessions integrated with the three plant powders compared to the control (Table 6).

Generally, Maize accessions TZM-136 and TZM-125 integrated with *P. guineense* as well as TZM-136 integrated with *A. squamosa* had no egg laid.

## 4. DISCUSSION

### *4.1. Integration of the Plant Powders*

The Integration of plant powders with the maize accession TZM-124 were not statistically different for mortality at 7 days (Table 1), a closer look at TZM-124, TZM-136 and TZM-125 revealed no adverse effect on the germinability of the maize grains when applied as protectants. This was consistent with what other investigators have found (Bello *et al*., 2000;[4] Araya & Emana, 2009;[11] Azeez, O.M. 2012).[12] The fact that the plant powders do not have adverse effects on the grains indicates the efficacy of the integrated powders. Ogendo *et al.* (2004)[13] reported that extracts and powders of several plant species have no adverse effects on the germinability of maize grain when applied as protectants especially *P. guineense*.

### *4.2. Progeny Production*

There was no progeny produced when TZM-124 and TZM-136 were integrated with *P. guineense, A. squamosa* and *V. amygdalina* and only a few emerged on TZM-125 (Table 2). According to Garcia-Lara *et al.* (2004)[14] Progeny emergence tended to be higher in susceptible grains than in resistant ones. In this study, F1 and F2 generation has no emergence of adult weevil in all the three maize accessions treated with the powders. This was consistent with the findings of Babarinde *et al.* (2008).[15]

**Table 6.** Efficacy of integrating three plant powders with three maize accessions against *S. zeamais* measured by the number of eggs laid at seven days

| | Maize accessions | | |
|---|---|---|---|
| **Plant powders** | **TZM-124** | **TZM-136** | **TZM-125** |
| *Piper guineense* | 75.00a | 100.00a | 85.00a |
| *Vernonia amygdalina* | 75.00a | 60.00a | 80.00a |
| *Annona squamosa* | 75.00a | 90.00a | 100.00a |
| Control | 0.00b | 0.00b | 0.00b |

Means followed by the same letter within a column are not significantly different at the 5% level of probability (Student – Newman-Keuls (SNK)).

### *4.3. Seed Germinability*

The seed germinability in this study of maize accession TZM-124 integrated with *P. guineense* recorded the highest seed germinability. All the maize accessions integrated with all the three plant powders recorded significantly higher percentage seed germinability and agreed with (Muhammad & Babatunde, 2015)[16] who reported efficacy of some spices as maize grain protectants against *Sitophilus zeamais Motsch.*

### *4.4. Mortality Rate*

The integration of resistant maize accessions with most active plant powders yielded high mortality at 28 days (75-100%) rate (Table 4). The ability of these plants to cause mortality of adult *S. zeamais* on maize grains might be attributed to the contact toxicity of the powder on the weevil as shown in Table 6. This agreed with Asawalam *et al.* (2006)[17] who recorded 79% (highest) mortality of *S. zeamais* treated with *P. guineense* on maize grains. Similarly, Udo (2005)[18] reported a significant mortality of *S. zeamais* induced by *P. guineense* suggested an excellent protectant potential of the plant while Okonkwo & Okoye (1996)[19] reported that *P. guineense* contains piperine and chavicine, which are insecticidal. Maize accessions TZM-136 integrated with *Piper guineense* and TZM-125 integrated with *Annona squamosa* produced 100% mortality after 7 days post treatment. No egg was laid on maize accessions TZM-136 integrated with *P. guineense* and *A. squamosa* as well as TZM-125 integrated with *P. guineense* and *V. amygdalina*.

## 5. Conclusions

Harvested grains need to be stored safely and scientifically in order to maintain its original quality while avoiding any spoilage by storage pests. In this case, effective management practice could have positive consequences for poverty alleviation and food security. The findings of this study revealed that three botanicals (*P. guineense, V. amygdalina* and *A. squamosa*) integrated with maize accessions were effective in reducing maize grains damage caused by *S. zeamais* and have positive protectant ability against the weevil. Therefore, they could be used as alternative insecticides against *S. zeamais* attacking maize grains during storage. Out of the three maize accessions maize accession TZM-124 integrated with *P. guineense* recorded the highest seed germinability. All the maize accessions integrated with all the three plant powders recorded significantly higher percentage seed germinability compared to the control. *Piper guineense, Annona squamosa* and *Vernonia amygdalina* should be integrated with resistant maize accessions for the control/management of *Sitophilus* *zeamais*. Farmers should be encourage to use the three plant powders integrated with maize accession for their maize storage especially maize accessions TZM-136 integrated with *Piper guineense* and TZM-125 integrated with *Annona squamosa* that produced 100% mortality after 7 days post treatment. The maize accessions and the plant powders could be incorporated into new maize breeds.

## Conflicts of Interest

The authors declare no conflict of interest.

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