ABUAD Journal of Engineering and Applied Sciences (AJEAS)
ISSN: 2992-5584
Volume 2, Issue 2, 102-106

Impact of Rice Husk Ash Bio-Pesticide Treatment on Germinability of Stored Maize Seeds Damaged by Maize Weevil (*Sitophilus zeamais*)

Bukola Dorcas Akinwumiju[1], Waleola Ayo AKINFIRESOYE[2], Raphael Abiodun ADEBAYO[1]

[1]*Crop, Soil and Pest Management, Federal University of Technology, Akure. Nigeria*
[2]*Agricultural Technology Department, Federal Polytechnic, Ile-Oluji, Ondo State.*

akinwumijubukola@gmail.com, walakinfiresoye@fedpolel.edu.ng, raadebayo@futa.edu.ng

*Correspondence: walakinfiresoye@fedpolel.edu.ng; Tel.: +2348033573716

Date Submitted: 14/12/2024
Date Accepted: 18/12/2024
Date Published: 31/12/2024

Abstract: *The residual effects of chemical pesticides on stored maize pose significant hazards to human health. This concern led to an investigation into the impact of Rice Husk Ash (RHA), a natural bio-waste, as a biopesticide treatment on the germinability of maize damaged by Sitophilus zeamais (S. zeamais). The research was conducted at the Laboratory of Crop, Soil, and Pest Management in the Department of the Federal University of Technology, Akure, Nigeria. Infested maize seeds were treated with three concentrations of RHA (1 g, 2 g, and 3 g) and germinated under controlled conditions. Data from the measured parameters for the germinability test were descriptively analysed using Microsoft Excel v.2013. The results showed a significant positive correlation between RHA concentration and the parameters measured for germinability. The highest mortality rate (83%) of S. zeamais was recorded at the 3 g RHA concentration, while the control treatment had the lowest mortality rate (7%). The highest germination percentage (98%) and rate (14%) of the treated maize were observed at the highest concentration of RHA (3 g), whereas the control recorded the lowest values of 46% and 7% for these parameters, respectively. Analysis of variance at a p-value ⩽ 0.05 revealed that RHA treatment significantly enhanced the germinability of stored maize. Therefore, RHA is recommended for use due to its cost-effectiveness and eco-friendly properties as a seed treatment against S. zeamais.*

Keywords: Rice husk ash, bio-pesticide, *Sitophilus zeamais*, maize germinability.

1. INTRODUCTION

Maize (*Zea mays*) is one of the essential crops in Nigeria and many other nations that are commonly consumed by every household [22, 6]. Aside from consumption, Maize also serves as a major raw material for agro-industries, as well as livestock feed [17, 5]. References [13, 3], more than 200 million populations in sub-Saharan Africa live on this staple crop. It is one of the five major crops in West Africa and one of the two most important cereals in Nigeria. However, one of the major challenges of its cultivation and production is the post-harvest losses as observed by [14, 16, 18, 1]. This observation was corroborated by [21] who discovered that Africa only contributed just 7 % to the global production of Maize. Reference [24] reports that climate is one of the reasons responsible for this low yield in Nigeria. Other reasons as observed by diseases [23] include the biological, chemical, and physical properties of the soil which may affect its growth and yield. Maize is always available during the rainy season, therefore, the harvested maize is stored all through the dry season for consumption, as raw materials for industries, for research purposes, and most importantly for replanting during the wet season. Unfortunately, [20] observed that pests and insects attack stored maize and destroy its nutritive value and germinability strength.

Reference [7,9] discovered in their study that about 14% loss in stored maize is recorded annually due to insect pests, especially Fall Armyworm (*Spodoptera frugiperda*) and maize weevil (*Sitophilus zeamais*) which were so destructive to maize on the farm and in the store respectively. *Sitophilus zeamais* followed the harvested maize from the farm or field to the store and boreholes in the grains to feed on the starchy endosperm causing weight loss, reduced quality, and making it unfit for replanting [8, 25]. Different methods have been used to mitigate the effect of *S. zeamais* on stored maize grains. This includes excessive drying of grains and spraying with insecticides. As good as the insecticides have been in controlling this pest, [11] observed the danger that the residues of these insecticides on the maize pose on human health. [10, 9] agreed on the toxicity of stored maize grains treated with insecticides. Hence there is need to seek alternative methods of mitigating the emergence of *S. zeamais* in storage which would not be hazardous to human health and will still have the nutrients of the stored grain intact for consumption and most importantly planting. This led to the investigation of Rice Husk Ash (RHA), a biological waste, as a potential biopesticide against maize weevil *Sitophilus zeamais* (*S. zeamais*) in stored maize.

The following questions were asked to chart a guide for the research:

a) Does Rice Husk Ash (RHA) treatment improve germinability by protecting stored maize from *S. zeamais* attack?
b) What is the optimal concentration of RHA needed for stored maize protection against *S. zeamais* attack?

The following hypotheses were formulated from the research questions at a *p-value* ≤ *0.05* significant level:

a) RHA biopesticide will improve germinability by protecting stored maize from *S. zeamais* attack
b) Increasing the concentration of RHA will enhance the germinability and *S. zeamais* mortality.

The study aims to investigate the impact of Rice Husk Ash (RHA) as a biopesticide on the germinability of stored maize infested with *Sitophilus zeamais.* The specific objectives were to determine;

a) the concentration level of RHA required for effective control of *Sitophilus zeamais*, and,
b) the efficacy of RHA on *Sitophilus zeamais* control.

2. MATERIALS AND METHODS

The experiment was conducted in the laboratory of the Department of Crop, Soil, and Pest Management at the Federal University of Technology, Akure, Ondo State, Nigeria. A completely randomized design (CRD) was employed, wherein treatment groups were randomly assigned to experimental units. The study consisted of two groups: the experimental group, which received treatment, and the control group, which did not receive any treatment. The independent variable was rice husk ash (RHA), while the dependent variables were the germination of *Maize seeds* and the mortality rate of *Sitophilus zeamais* (*S. zeamais*).

Rice husk (RH), clean maize, and *S. zeamais*-infested maize were sourced from a rice mill located at First Gate, Army Barracks, Ondo Road, Oja Oba, and Onyearugbulem Market, all in Akure respectively. The RH was turned into ash in a furnace at 550 °C and stored in a tightly sealed container after cooling. One kilogram of clean maize was infested with 50 pairs of adult *S. zeamais*, sieved from the infested maize. After 21 days of incubation in a closed jar, the adult weevils were removed from the grains, and the grains were left inside the jar for an additional 21 days to allow for the emergence of new *S. zeamais*. The newly emerged weevils (*S. zeamais*) were subsequently sieved from the grains after the incubation period, and these were the pesticides to be used for the experiment.

Weights of 1 g, 2 g, and 3 g of RHA were added to three jars labelled B1, B2, and B3, respectively. Twenty seeds of clean maize were placed in each jar and shaken to ensure an even distribution of RHA over the seeds. The jars were left for about 1 hour to settle before ten new emergent S. zeamais were introduced into each. Thus, each jar contained 20 seeds of maize, the specified grams of RHA, and 10 S. zeamais. The jars were covered and left for 24 days. Afterward, the S. zeamais were sieved out of the jars to count how many were alive compared to the 10 introduced for the mortality rate. The number of damaged grains, indicated by holes bored into the seeds, was also counted to identify damaged seeds and serve as a precursor to the germination test. The undamaged seeds were planted in a nursery, and the emerging seedlings were counted. This procedure was replicated for two additional sets of treatments, C1, C2, C3, and D1, D2, D3. Additionally, the control group was labelled A1, A2, and A3, which underwent the same procedure without adding RHA.

The Mortality Rate (MR), Germination Percentage (GP), Germination Rate (GR), and Germination Index (GI) were determined using Equations (1), (2), (3), and (4) according to [2], [12], [4].

a) $$MR\ (\%) = \frac{No\ of\ dead\ Insects}{Expected\ No\ of\ live\ Insects} \times 100 \quad (1)$$

b) $$GP\ (\%) = \frac{No\ of\ Germinated\ Seeds}{Total\ No\ of\ Seeds\ Tested} \times 100 \quad (2)$$

c) $$GR\ (\%) = \frac{No\ of\ Germinated\ Seeds}{Total\ No\ of\ Seeds\ tested} \times \frac{1}{No\ of\ Days\ to\ Germination} \times 100 \quad (3)$$

d) $$GI = \frac{\sum(No\ of\ Germinated\ Seeds)}{Number\ of\ Days\ to\ Germinate} \quad (4)$$

The data were analyzed descriptively using Microsoft Excel (2013 version) and IBM SPSS Statistics (version 28). A one-way analysis of variance (ANOVA) was conducted to compare the means of the dependent variable (*S. zeamais*) across the different levels of the independent variable (RHA).

3. RESULTS AND DISCUSSION

3.1 The Mortality Rate (MR)

It was discovered, as shown in Figure 1, that the MR of *S. zeamais* was significantly affected by the application of RHA as a biopesticide. This is so because the MR increases as the RHA content increases. For example, the MR of the *S. zeamais* was 83% when the RHA concentration was 3 g. It was 60% when the RHA was 2 g and just 27% when the RHA was 1 g. The control was 7% which is lower when compared to the different rates of RHA. It was discovered from this result that increasing the concentration of RHA will enhance the germinability and mortality of *S. zeamais*.

The higher the concentration of the RHA, the higher the mortality rate of *S. zeamais.* This was the same observation as [22] in a related study.

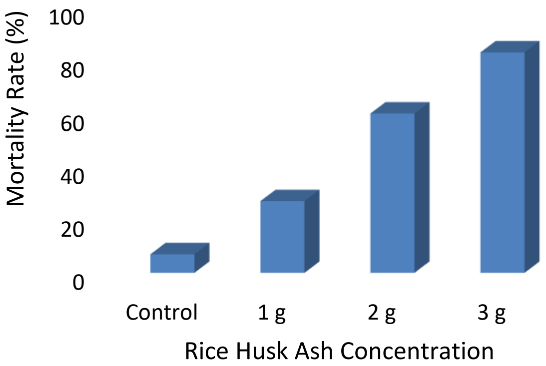

Figure 1: Effect of rice husk ash on mortality rate of *S. zeamais* infested maize

The correlation matrix showed a significant positive correlation between the concentration of RHA and MR with a correlation coefficient (r) of 0.995. The MR of *S. zeamais* from this study is directly linked to the germinability of stored maize. The higher the MR, the higher the number of maize seeds not damaged by the pest, and the healthier the seeds are for germination. This indicates that RHA biopesticide is effective in controlling *S. zeamais* population.

3.2 The Germination Percentage (GP)

The GP of maize seed was also significantly affected by the application of RHA biopesticide. As shown in Figure 2, the GP increases as the RHA concentrate increases. While the GP of the control remained about 46%, that of the RHA of 1 g was around 65%, that of the 2 g RHA was about 80%, and 98% for the 3 g RHA. It is shown here that the GP for the control was the lowest (46%). As corroborated by [15] in their study where they observed that a higher concentration of bio-pesticide increases the percentage of seed germination.

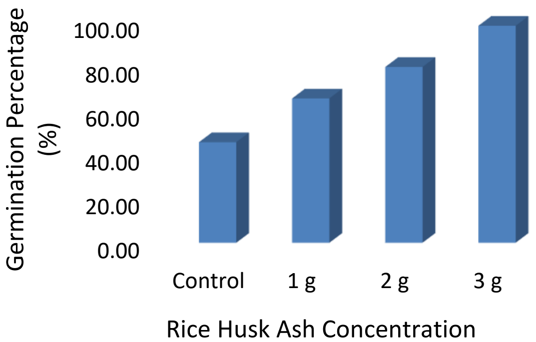

Figure 2: Effect of rice husk ash on germination percentage of maize infested by *S. zeamais*

It was observed that there was a strong positive correlation between RHA concentration and the germination percentage with a correlation coefficient (r = 0.998). This result indicates that the RHA biopesticide accelerates the germination process of maize seeds.

3.3 The Germination Rate (GR)

The GR of maize seeds under study was equally significantly affected by the application of RHA biopesticide. The results showed that the highest germination rate (14%) was recorded at 3 g of RHA concentration as shown in Figure 3. The control treatment had the lowest germination rate of about 7% when compared to GR of 9.34% and 11.38% for 1 g and 2 g of RHA concentration respectively. This shows that a higher concentration of RHA bio-pesticide significantly improves the GR of stored maize whenever they are planted.

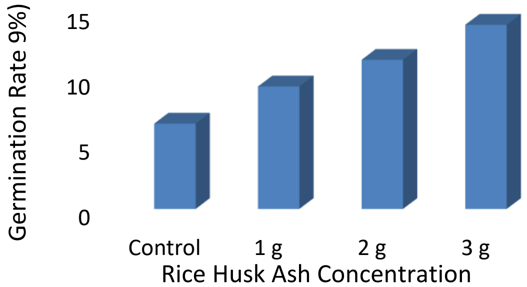

Figure 3: Effect of rice husk ash on germination rate of maize infested by *S. zeamais*

The higher the concentration, the higher the germination rate. This finding corroborates the work of [22] showing that a higher concentration of biopesticides increases the germination rate of the crops under investigation. It is seen here that the RHA biopesticide accelerates the germination process of maize seed since the seeds are healthy for planting.

3.4 The Germination Index (GI)

The GI of maize seeds was calculated to assess the overall germination performance. The result showed that the GI as presented in the bar chart of Figure 4 showed that the GI increased significantly with increasing RHA concentration. This shows the level of speed and uniformity of the germination of the seed under investigation.

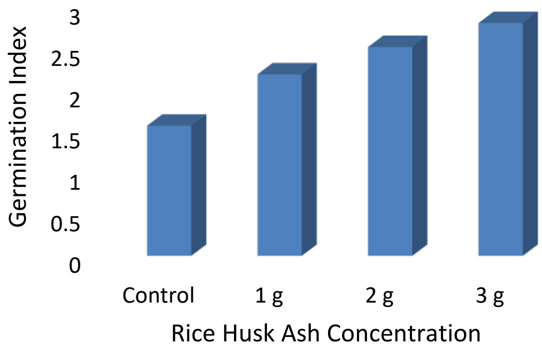

Figure 4: Effect of rice husk ash on germination index of maize infested by *S. zeamais*

While the GI of the control was 1.57, the highest GI (2.81) was obtained from 3 g of RHA. Whereas, the GI for 2 g and 1 g of RHA were 2.52 and 2.19 respectively. A strong positive correlation was observed between RHA concentration and the GI (r = 0.98). This result suggest that the RHA biopesticide has a positive effect on the germinability of maize seeds damaged by *S. zeamais*. The biopesticide not only controls *S. zeamais* populations but simultaneously enhances the GI.

3.4 Analysis of Variance

The result of the analysis of variance (ANOVA) at P-value ≤ 0.05 as presented in Table 1 revealed a significant difference in the mortality rate (p = 0.02), germination percentage (p = 0.00073), germination rate (p = 0.0022), and the germination index (p = 0.31).

Table 1: ANOVA – effect of RHA on germinability of maize infested with *S. zeamais*

Parameters Measured	*F*	*P-value*
Mortality Rate	8.871	0.025*
Germination Percentage (%)	39.999	0.00073*
Germination Rate (%)	26.286	0.0022*
Germination Index	1.224	0.0331*

**significant and **not significant at p-value ≤ 0.05*

The ANOVA showed that RHA biopesticide improves the germinability of maize seed by protecting it against *S. zeamais.*

4. CONCLUSION

Rice Husk Ash (RHA) by this research is a good bio-pesticide against *S. zeamais,* without any side effect to human health. The findings of this study indicate that RHA treatment can significantly protect the emergence of *S. zeamais* and improve the germination percentage and rate of *Zea mays* respectively. It was observed that the higher the RHA concentration, the higher the mortality rate of *S. zeamais,* and the faster and more uniform the germination of *Zea mays*. The RHA biopesticide controls *S. zeamais* population and equally enhances the germination percentage, rate, and index of maize seeds. The use of RHA as a treatment for stored maize can be cost cost-effective and environmentally friendly approach to improving seed quality and reducing storage losses. It is recommended that further research should be carried out to investigate the optimal concentration of RHA and treatment for different maize varieties and storage conditions.

ACKNOWLEDGEMENT

The HOD and staff of Crop, Soil and Pest Management Department of Federal University are appreciated for their valuable contribution to this study. We also acknowledged the support from the HOD and the Technologists of Agricultural Technology Department of Federal Polytechnic, Ile-Oluji.

REFERENCES

[1] Affognon H, Mutungi C, Sanginga P, Borgemeister C (2015). Unpacking postharvest losses in Sub-Saharan Africa: A Meta-analysis World Development 66:49-68

[2] Akinbuluma M.D. (2020): Volatile Oils from *Cedrela odorata L.* as Protectants against *Sitophilus zeamais* (Coleoptera: Curculionidae). *American Journal of Essential Oils and Natural Products.* 8: 20–24

[3] Akhigbe, C.I., Oyerinde, A.A., Asala, S.W. and Anjorin, T.S. (2021). Evaluation of Fall armyworm (*Spodoptera Frugiperda* J. E. Smith) Infestation and Efficacy of Neem Extracts In Maize (*Zea Mays L.*). *Nigerian Agricultural Journal.* Vol. 52 (1) Pg. 77-82

[4] Association of Official Seed Analysts (AOSA). (2019). Seed Vigor Testing Handbook.

[5] Bathla, S., Jaidka, M., Kaur, R. (2019): Nutritive Value. In (Ed.), Maize – Production and Use. *IntechOpen*. https://doi.org/10.5772/intechopen.88963

[6] Cadoni, P. and Angelucci, F. (2013). Analysis of Incentives and Disincentives for Maize in Nigeria. Technical notes series, MAFAP FA, Roma. Pp. 6-9

[7] DeGroote, R. S., Wilson, M. A. and Boumans, R. M. J. (2002). A Typology for the Classification, Description and Evaluation of Ecosystem Functions, Goods and Services. *Ecol Econ*., 41(3):393–408.

[8] Edelduok, E.G., Akpabio, E., Eyo, J.E. and Ekpe, E.N. (2015) Evaluation of the Insecticidal activities of Cotyledon Powder of Melon, Citrullus vulgaris Schrad against the Maize Weevil, *Sitophilus zeamais* Motschusky. *Journal of Biopesticides and Environment.* 50-57.

[9] Hagstrum, D.W., Phillips, T.W. and Cuperus, G. (2012) Stored Product Protection. Kansas State University. 2012. ISBN 978- 09855003-0-6. 8.

[10] Iken, J.E. and Amusa, N.A. (2004). Maize Research and Production in Nigeria. *African Journal of Biotechnology*. Vol. 3 (6), pp. 302-307.

[11] Ileke, K.D., and Oni, M.O. (2011) Toxicity of some Plant powders to Maize Weevil, *Sitophilus zeamais* (Coleoptera: Curculionidae) on Stored Wheat Grains. *African Journal of Agriculture Research.* 2011;13(6):3043-3048

[12] International Seed Testing Association (ISTA). (2019). International Rules for Seed Testing.

[13] Kehinde, I. K. (1999). Agronomy of Upland and Lowland Rice in Nigeria, Paper Presented at the Special Rice Production Project (SRPP) held at APMEU, Kaduna, 26–28 April, 1999.

[14] Kitinoja, L., Dandago, M. A. and Abdullahi, N. (2019). Postharvest Loss Assessment of Maize (*Zea mays*) along its Value Chain in Nigeria. *Journal of Stored Products and Postharvest Research.* Vol. 10(1), pp.13-19.

[15] Kumar, J. Ramlal, A., Mallick, D. and Mishra, V. (2021). An Overview of Some Biopesticides and

their Importance in Plant Protection for Commercial Acceptance. *Plants* 2021, 10, 1185.

[16] Lobulu, J., Shimelis, H., Laing, M. and Mushongi, A. A. (2019). Maize Production Constraints, Traits Preference and Current Striga Control Options in Western Tanzania: Farmers' Consultation and Implications for Breeding. *Acta Agriculturae Scandinavica* B 69: 734–746.

[17] Makate N. (2010): The Susceptibility of Different maize Varieties to post-harvest Infestation by *Sitophilus zeamais* (MOTSCH) (Coleoptera: Curculionidae). *Scientific Research and Essay* 5: 30–34.

[18] Obour, P.B., Arthur, I.K. and Owusu, K.T. (2020): Maize production Failure in Ghana: A Case Study of Ejura – Sekyedumase municipality. *Sustainability* 14: 3514.

[19] Okparavero, N.F., Olagunju, O.D., Odutola, B.S., Haruna, P.B., Akande, E.T. and Okunade, S.O. (2022). Assessment of Damage and Insect Infestations on Maize Grains in Three Markets within Ilorin metropolis. *Journal of Entomology and Zoology Studies*; 10(1): 286-289

[20] Pimentel, D. (2007). Area-wide Pest Management: Environmental, Economic and Food Issues. In: *Vreysen RAS, Hendrichs M, B. J (eds)* Area-wide control of Insect Pests. Springer, Netherlands, Pp 35–47.

[21] Ragasa, C., Chapoto, A. and Kolavalli, S. (2014). Ghana Strategy Support Program: Maize Productivity in Ghana. International Food Policy Research Institute Policy Note 5. 4 pp.

[22] Sintimi, H. O. and Ansah, K.D. (2023). Effects of Biopesticides extracted with a Homemade Solvent on stored Maize Protection. *Agricultura Tropica Et Subtropica*, 56 OV, 125–142.

[23] Suleiman, R.A., Rosentrater, K.A. (2015). Current Maize Production, Postharvest Losses and the Risk of Mycotoxins Contamination in Tanzania. International Meeting. American Society of Agricultural and Biological Engineers.

[24] World Bank (2009). Eastern Africa: A Study on the Regional Maize Market and Marketing Costs. Report No. 49831.

[25] Trematerra, P., Ianiro, R., Athanassiou, C.G. and Kavallieratos, N.G. (2013). Behavioral Responses of *Sitophilus zeamais* Motschulsky Adults to Conditioned Grain Kernels. *Journal of Stored Products. Res.* 2013;53:77-81. 2013