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EFFECTS OF *ZINGIBER OFFICINALE* AND *ALLIUM SATIVUM* AS BIOPRESERVATIVE AGAINST WEEVIL (*SITOPHILUS ORYZAE*) INFESTED RICE GRAINS

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ABSTRACT: *The effect of Zingiber officinale and Allium sativum against adult rice weevil (Sitophilus oryzae) was conducted using dried powdered bulbs and rhizomes of garlic and ginger to ascertain its effectiveness in preservation of stored rice grains. The samples include ginger treated rice grains, garlic treated rice grains, and ginger and garlic treated rice grains at concentrations of 2g, 4g and 6g of the powdered experimental plant materials. The ginger and garlic treated rice grains was prepared at the ratio of 50%Zo : 50%As and the control sample was preserved without treatment. Mortality rate of adult S. oryzae was determined daily for a period of 21 days and compared with the control. The results shows that mean mortality of adult S. oryzae treated with two plant powders (Z. officinale and A. sativum) at various concentrations ranged from 1.22±1.093 to 1.44±0.882, 1.56±0.726 to 2.56±1.014 and 1.56±0.726 to 2.22±1.481 for ginger treated rice grains, garlic treated rice grains, and ginger and garlic treated rice grains, respectively. The lethal effect at 7 days interval was also determined and the result revealed that the mortality was highest at 21 days and least at 7 days of post treatment for Z. officinale; while A. sativum treated sample revealed that the mortality effect of was highest at 7 and 21 days and least at 14 days of post treatment. When the lethal effect was compared, A. sativum powder caused higher mortality of adult S. oryzae than Z. officinale. These results suggest that these plants are suitable for possible exploitation in protecting stored rice from damage by storage insects.*

KEY WORDS: rice weevil, bio-pesticide, lethal effect, mean mortality, eco-friendly.

INTRODUCTION

Rice is a staple food in many countries of Africa and constitutes a major part of the diet in many others. During the past three decades, the crop has seen consistent increases in demand and its growing importance is evident in the strategic food security planning policies of many countries. With the exception of a few countries that have attained self-sufficiency in rice production, rice demand exceeds production and large quantities of rice are imported to meet demand at a huge cost (Oteng, 1997). Africa's inability to reach self-sufficiency in rice production is the result of several major constraints in the rice industry which require urgent redress to stem the trend of overreliance on imports and to satisfy the increasing demand for rice in areas where the potential of local production resources is exploited at very low levels.

Thus, one major factor militating against this self-sufficiency in rice production is the inability to maintain quality of the crop during storage. Worldwide, rice is continuously attacked by several insect pests during storage (Ishii *et al.,* 2010). Rice weevil (*Sitophilus oryzae L.*) is a common weevil and it is one of the most important storage pest which causes severe damage to cereals throughout the world (Thomas *et al.,* 2002). Both white and brown rice are susceptible to the rice weevil, as the adults feed on rice and the larva develops inside the rice kernel. The female of the rice weevil bores a hole in the kernel, lays the egg inside, and seals the hole with a gelatinous secretion which protects the egg (Lucas and Riudavets, 2002). They cause losses to grain in storage, either directly through consumption of the grain or indirectly by producing 'hot spots' causing loss of moisture and thereby making grain more suitable for their pests (Das, 2013). They also cause damage to grains which are stored at 25-30 °C and at low relative humidity as these conditions favor the development of this pest (Akunne *et al.,* 2014). One pair of the rice weevil can reproduce about one million of its species within a period of three months under favorable conditions. A larva consumes 14mg grain/d and in its adult stage, consumes 0.4mg grain/d. While the quantity of grain consumed and the loss cumulatively is very high, the quality of grain remaining after the attack becomes very poor as the rice weevil reduces the nutritive value of the grain (Thomas *et al.,* 2002).

The efficient control of stored grain pests has long been the aim of entomologists throughout the world. Over the years, synthetic chemical pesticides have provided an effective means of pest control. The short-comings of the use of chemicals (Onoja, 2015) and the potential hazards on mammals increased concern by consumers over insecticide residues in processed cereal products, the occurrence of insecticide-resistant insect strains, the ecological consequences, increasing cost of application and the precautions necessary to work with chemical insecticides all call for new approaches to control stored-product insect pests (Asawalam, 2012). Hence, the present study aim to evaluate the effect of ginger and garlic powder, independently and in combination, as natural preservative against rice weevil (*Sitophilus oryzae L.*).

MATERIALS AND METHODS

Pre-handling of Rice Sample

Rice grains were purchased locally from the market and properly examined for infestation of *S. oryzae*. The rice grains were carefully cleaned and freed of all extraneous materials as well as damaged nuts prior to use.

Pre-handling of Garlic and Ginger

The garlic (*Allium sativum*) bulbs and ginger (*Zingiber officinale*) rhizomes were locally purchased from the market. The plant materials were cut into smaller parts, spread on a tray and dried in a cabinet dryer (Sheldon Lab Oven: VWR 1370) at 50^{o}C for 1 hour. After drying, the plant samples were ground using electric blender and sieved to obtain fine powders. The plant powders were put in air tight containers separately to ensure that the active ingredients were not lost. The powders were stored in a cool dry place until when needed.

Insect Culture

Infested rice grains were purchased locally from the market. The adult *S. oryzae* used for the experiment were obtained and cultured in a plastic container under ambient laboratory temperature of 27±2ºC and 75±2% relative humidity, stored in the culture vial (19cm in diameter), and kept in the laboratory cupboard so that the old insects will mate and oviposit. The experiment was left undisturbed until the emergence of adults. The newly emerged adults were used for further experiments.

Effect of Garlic and Ginger Powder on Mortality of *S. oryzae*

Thirty grams (30g) of garlic treated rice grains, ginger treated rice grains, and garlic and ginger treated rice grains were measured into separate white transparent plastic containers with perforated lids to allow ventilation. To achieve the treatments, 2g, 4g and 6g concentrations of the experimental plant powders were added into various containers holding 30g of rice grains and shook vigorously to mix thoroughly. The same was done with mixtures of the powders (2g, 4g, and 6g at 50%Zo and 50% As). A control of 30g of rice which was not treated with the plant powders were also measured into the same type of container and stored under same environmental conditions. Ten newly emerged unsexed adult *S. oryzae* were introduced into each of the experimental containers including the control. The time and degree of infestation were recorded, and the mortality count of adult *S. oryzae* in the rice grains of various treatments were also observed on daily basis for 21 days. All tests were carried out in triplicates.

Data Analysis

Data generated were analyzed using one-way analysis of variance and mean separation was done by Duncan's new multiple range test and paired t-tests. Significant difference was accepted at $p < 0.05$.

RESULTS

Effect of Concentrations of Ginger (*Z. officinale*) and Garlic (*A. sativum*) on *S. oryzae*

The result of the mean mortality of adult *S. oryzae* treated with two plant powders (*Z. officinale* and *A. sativum*), differently and in combination (50% Zo and 50% As), at concentrations of 2, 4 and 6g after 21 days are presented in Table 1.

Table 1: Mean Mortality of *S. oryzae* in rice grains treated with *Z. officinale* and *A. sativum*

Conc. (g)	**Mean Mortality of *S. oryzae* ± SD**		
Ginger Treated	**Garlic Treated**	**Ginger/Garlic Treated**	
~~Control~~	~~Nil~~	~~Nil~~	~~Nil~~
2g	1.22±1.0^{a}	1.56±0.7^{b}	1.56±0.7^{b}
4g	1.67±1.1^{a}	2.11±1.5^{bc}	1.67±1.0^{b}
6g	1.44±0.8^{a}	2.56±1.0^{c}	2.22±1.4^{b}

Columns sharing similar superscripts are not significantly different (p >0.05)

The result indicates that the mean mortality of adult *S. oryzae* (1.67±1.1) was recorded highest in rice grains treated with 4g concentration of *Z. officinale* rhizome powder followed by those of 6g (1.44±0.8), while no mortality was observed in the control sample. The result revealed that the mortality of *S. oryzae* with *Z. officinale* does not vary in a dose dependent manner. The result *A. sativum* indicate that the highest mean mortality of adult *S. oryzae* (2.56±1.0) was recorded with the 6g concentration followed by 4.0g (2.11±1.5) and no effect in control sample. Thus, the result revealed that the mortality of *S. oryzae* with *A. sativum* vary in a dose dependent manner. Combination of ginger and garlic (50% Zo and 50% As) treated sample against adult *S. oryzae* show highest mean mortality at 6g (2.22±1.4) while the lowest mortality was recorded for 2g (1.56±0.7).

Figures 1 and 2 shows the mean mortality of *S. oryzae* in rice grains treated with *Z. officinale* and *A. sativum* at 7 days intervals. Figure 1 revealed that the mortality was highest at 21 days and least at 7 days of post treatment; while Figure 2 revealed that the mortality effect of was highest at 7 and 21 days and least at 14 days of post treatment. When the lethal effect of the plant materials against *S. oryzae* were compared (Figure 3), the result revealed that *A. sativum* powder caused higher mortality of adult *S. oryzae* than *Z. officinale*. However, there was no significant difference between effect of the two plant powder against adult *S. oryzae* (p >0.05).

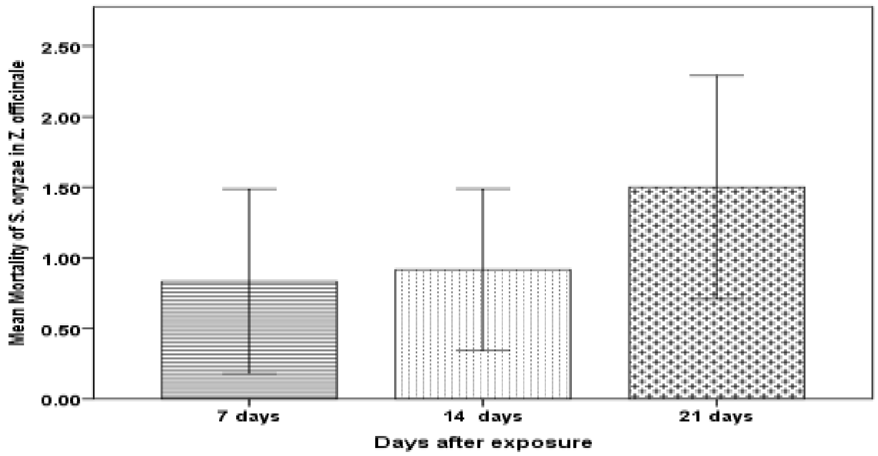

Figure 1: Mean mortality of *S.oryzae* in rice grains treated with *Z. officinale* at 7 days intervals

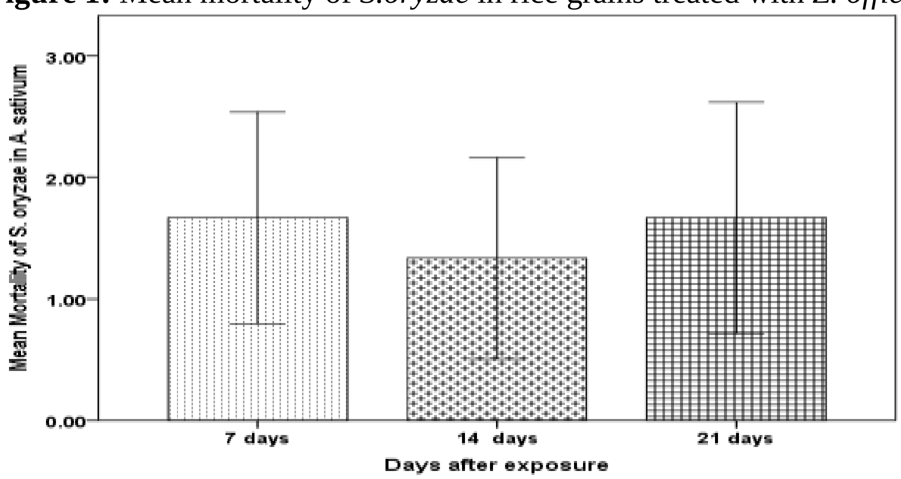

Figure 2: Mean mortality of *S. oryzae* in rice grains treated with *A. sativum* at 7 days intervals

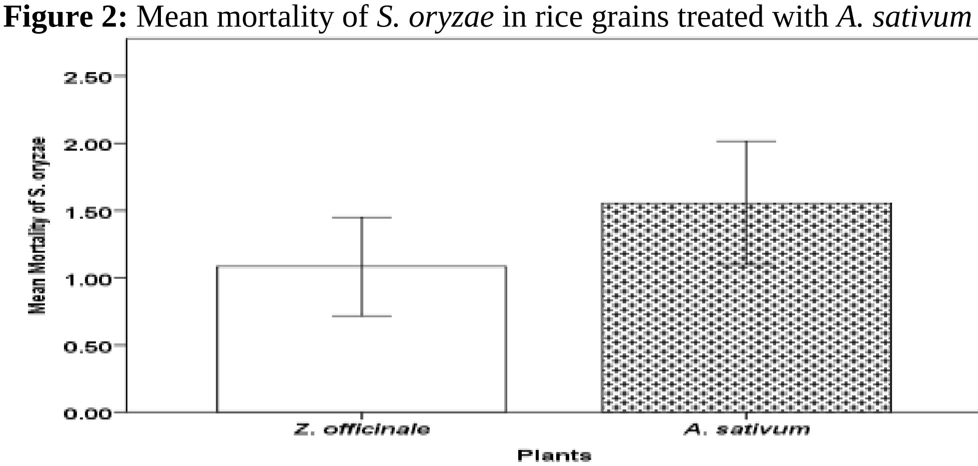

Figure 3: Comparative mean mortality of *S. oryzae* in rice grains treated with *Z. oficinale* and *A. sativum*

DISCUSSION

The results of this experiment indicates that the bulb and rhizome powders of *A. sativum* and *Z. officinale* when used as pest control agents caused the mortality of adult *S. oryzae* and increased preservation potential of the rice grains. The study supports the fact that insecticides of plant origin can serve as an eco-friendly alternative to synthetic insecticides in the control of rice weevil. Asawalam *et al.* (2012) also reported that rhizome powder of ginger and powders of other plant materials are capable of blocking the spiracles of various plant insects and this can lead to suffocation and death. Meles *et al*., (2012) reported that garlic is toxic to most insects due to its salphone hydroxyl ion content which penetrates the blood brain barrier. He also reported that garlic has anti-feedant property and so inhibits the normal feeding behavior of most insect pests. In the present study, the significant difference obtained in the mortality of *S. oryzae* by comparing the efficacy of *A. sativum*, and *Z. officinale,* with the control is an indication that *A. sativum* bulb and *Z. officinale* rhizome powders have insecticidal properties capable of controlling pests of stored rice. It also shows that garlic and ginger have a synergistic effect in controlling rice weevil.

Various potentials of ginger and garlic as preservative agents have been studied in many foods and for numerous purposes. Vwioko *et al.* (2013) studied the effect of garlic and ginger phytogenics on the shelf life and microbial contents of homemade soursop (*Annona muricata* L) fruit juice. The study stated that the soursop juice without treatment (T1) was used as the control while others in four replicates were separately treated with 50 mg/ml garlic (T2), 50 mg/ml ginger (T3), mixture garlic and ginger in equal proportion of 50 mg/ml each (T4) and 10 mg/ml (T5) sodium benzoate respectively. They concluded that the treatment of freshly prepared soursop juices with sodium benzoate, and a mixture of garlic and ginger improved storage span and reduced health risks of infection and/or intoxication from their consumption.

Similarly, Olaniran (2013) who studied the effect of ginger and garlic as biopreservatives on proximate composition and antioxidant activity of tomato paste noted that the free radical scavenging activities increased in tomato paste samples containing blend of 2% garlic and 2% ginger (53.23 - 80.49 mg VCE/100 g) and blend of 2% garlic and 4% ginger (65.42 - 88.31 mg VCE/100 g). The combination of garlic and ginger as biopreservatives also increased the total phenolic and lycopene contents of tomato paste samples. The study further stated that the use of garlic and ginger as biopreservatives either separately or in combination increased fats, lycopene and total antioxidative capacity of tomato paste during storage.

Hence, this previous works has shown the effectiveness of garlic and ginger in food preservation. The exposure of the weevils to the garlic powder in the present study caused mortality in a concentration-dependent fashion. This finding is in line with the report given by Prowse *et al.* (2006) who reported that on two species of dipteran insects studied, their mortality was highest in the highest concentration of garlic extract. Between the two plant powder used, garlic recorded the highest mean mortality of 2.56 when compared to the mean mortalities recorded by ginger, their mixture and the control (1.67, 2.22 and nil respectively). This is in accordance with the findings of Meles *et al.* (2012) who recorded that garlic was the best insecticide as compared to other plant extracts because, it could be used as eco-friendly alternative to DDT.

CONCLUSION

Natural methods of plant protection are assuming new importance as an alternative to these commercial synthetic products. This study has shown the efficacy of bulb powder of garlic and rhizome powder of ginger in the control of adult *Sitophilus oryzae.* This revealed that the tested plant materials has lethal effect on the insect pest of stored product especially rice and thus could serve as a protectant. They would also yield environmentally sound pesticides having no harmful effects on the non-target organisms. More so, the need for effective food security measures and the need to reduce risk of post-harvest losses have given rise to alternative means of storage which meets the local needs of a region. The insecticidal effects of these botanicals and potential for their local availability make them attractive candidates in upgrading traditional postharvest protection practices. Additionally, consumption of extracts from these plants, especially the ones used in this study, is beneficial for human beings. There is need to search for more of these safe and effective biodegradable pesticides with non-toxic effects on non-target organisms.

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