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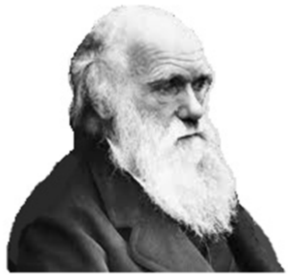

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Effect of wood ash, river sand, mineral oil and dry pepper (*Capsicum* spp) dust on the population of *Sitophilus zeamais* (Motschulsky, 1855) (maize weevil) in maize grain storage

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ABSTRACT

An experiment to evaluate the effect of wood ash, river sand, mineral oil, and dry pepper (*Capcium* spp) dust on the population (control) of *Sitophilus zeamais* (Motschulsky, 1855) (Coleoptera: Curculionidae) (maize weevil), was conducted. The experiment was laid out in a Completely Randomized Design (CRD) consisting of five (5) treatments; 0 g, 5 g river sand, 5 g dry pepper dust, 5 g wood ash, and 5 g mineral oil. All treatments were replicated three times. Data were taken on the number of population of *Sitophilus zeamais* emerging from individual treatments. Herein, weight loss on grain maize was taken for *S. zeamais* infestation. The effect of the various treatments on maize seed with *S. zeamais* was not significant ($P>0.05$), although the highest population numbers of the weevil was recorded in the control (0 g). Zero population of *S. zeamais* was recorded in wood ash treatment at 5 g, which significantly ($P<0.05$) protected the grains over the control. Significant (higher) weight loss was recorded in the control since no treatment was applied. All treatments, except the control, indicate the potential of reducing (controlling) weevil numbers. Data obtained in these experiments reveal that wood ash, pepper dust, and river sand produced the most protective/control effect on the population of the weevil over the control. Results of the study show that river sand, pepper dust, wood ash, and mineral oil (vegetable oil) performed positively, and hence, exerting protectant properties on maize grains.

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***Keyword*:** Control, corn, effect, food, pest, population, quality, *Sitophilus zeamais*, treatment, *Zea mays, Hymenocardia acida*

1. INTRODUCTION

Maize is one of the crops that have played a key role in both, human development and nutrition. Maize is also known as corn with its origin from Mexico and Central America about 5,000 to 7,000 years ago (Brewbaber, 2003), from where the crop spread to all parts of the globe. Maize belongs to the grass family *Poaceae*, with its botanical name as (*Zea mays* L.). Maize is cultivated extensively in the United States, giving an annual average of production at 310 million metric tons, with its world production of 177.3 million tons and yield of 3.6 tons/acre (Brewbaber, 2003).

The crop is numbered as 3rd, following rice, with wheat being the first one. Apart from the United States, other countries of large maize production include; China, which produces 20% of World maize. Brazil, Argentina, India, France, Canada, including Italy, have been also identified as countries with large maize production (Brewbaber, 2003). Nigeria has been identified as one of the leading countries of maize production in the Sub-Saharan Africa.

Nigeria produces maize across all her agro-ecological zones, with more production in the Northern part of the country. Various literature views have pointed 48% of land area (hectares) in Nigeria being intensively cultivated to maize. About 60% of Nigerian maize is utilized by industries for production of maize product and related by-products. The production of maize in Nigeria has boosted income of farmers, and the country at large, creates wealth to both, individual and Government, improves standard of living, reduces poverty level and extensively improves food development and security. Maize has largely tuned to be a local "cash crop" in Nigeria, replacing crops like sorghum and millet, which was confirmed by the study of Smith *et al*. (1999). Maize contains a high percentage of carbohydrate, fat, including enzymes and vitamins. Calcium, iron, carotene, thiamine, riboflavin, niacin, electrolytes are also contained in maize. Osundahunsi and Awah (2000) survey confirm that the crop contains antioxidant in its oil, which gives it wide uses. Corn oil has wide uses, which include: cooking, manufacturing of soaps, making of gum. Maize starch is used in cosmetic industries for production of body spray, and other maize related by-products, the crop starch is used as diluents in pharmaceutical industries. Kumar and Jhariya (2013) investigation confirms the use of corn/ corn extract in production of alcohol and paper. A study by Watson (1988) indicates that maize has the potential to produce large amount of ethanol fuel, with its by-products largely used in animal nutrition (feeding/feed formulation). The ever increasing economic uses and high utilization of maize makes the crop worth researching on.

Over the years a considerable amount of food/feed has been lost due to pest attack during storage, with a huge impact being felt in food/feed quality/quantity loss, including its contribution to the global food wastages/shortages. The report of Giga *et al*. (1988) pointed-out storage pest been a hindrance to successful food/grain storage and availability.

The vast losses of quality (reduction in nutritive and economic value) of a crop during storage are numerous and vary from location-to-location and from environment-to-environment. Losses during storage affect greatly the quality and quantity of food/feed. Food quality loss may depend on storage structure, the storage environment, crop handling after harvest, and other related factors. Excessive heat, high moisture content, poor ventilation, nature/structure/component of storage materials affect food grain storage. Insects, fungi, bird and rodent have been identified as factors affecting grain quality during storage. Weight loss/quality reduction in maize grain during storage is about 10.8% and this pose a serious threat to food quality/security in the tropics; these findings were also examined by Giga *et al*. (1988).

The cosmopolitan maize weeil, *Sitphilus zeamais* (Motschulsky, 1855) (Coleoptera: Curculionidae) has been pointed out as a serious pest of maize grain and other cereals during storage (Demissie *et al*., 2008; Danho *et al*., 2003). About 24.5% losses in germination, low market value, including reduced nutritive value in maize grain have been reported by Jean *et al*. (2015). Increasing losses have been observed over the recent decades in Cameroon, causing about 33% of damaged grains (Nukenine *et al*., 2002), similar report have been recorded in numerous research literature about grain storage pests in Nigeria, with serve cases being observed in Obubra and its environs. As a measure to protect agricultural crops against insect pest, a considerable amount of synthetic residual insecticide have been used here-and-there around the globe.

The chemicals though effective also poses serious environmental and health challenges to humans (Subramanyam *et al*., 1995; Park *et al*., 2003). Furthermore, these chemicals are not easily available apart from the poor-resource nature of the local farmers, especially in the developing world, coupled with wrong application procedures being reported. The challenges associated with synthetic insecticide have intensified the search into alternative measures of controlling insect pest both, in storage and in the field (Isman *et al*., 2006; Obeng-ofori, 2007).

There is a variety of materials, including mineral substances, that cause injury to the protective wax layer of store pests, thereby causing desiccation. As these substances fill in the spaces between the grains, movement is hampered in attempts to locate sex partner, respiration is reduced, with a result making survival of these pest difficult, and this has also been reported by Anonymous (1984).

Wood ash is one of the effective measures of pest reduction/control for preservation of food quality. This method, although mostly traditional but still helps in the areas with low technology and income. An investigation by Kalshoven (1981) presented wood ash as being effective over the control of maize weevil, where the researcher observed an imped hatching of nematode eggs. A protection of stored produce with vegetable oil is a simple approach and a low cost method (Pandey *et al*., 1981); this protectant does not damage the germinating capacity of seed/grains. River sand, and other related bio-substances, including pepper dust, can also enhance grain quality during storage. Against the bedrock of rapid misuse and abuse of synthetic chemicals during food preservation and storage, the argument for conducting this study on biological materials arises, in other to enhance food security and food quality.

The objective of this research is to find possible measures of preserving maize quality during storage, using locally sourced materials: wood ash, river sand, mineral oil, and dry pepper (*Capsicum* spp.) dust, in other to preserve maize grain in storage against *Sitophilus zeamais* destruction (O. M. Obembe, 2017).

2. MATERIALS AND METHOD

The experiment was conducted at the Faculty of Agriculture and Forestry, Cross River University of Technology (CRUTECH), Nigeria during 2014 and 2015 season. The study area lies between Latitude 6°06' North and Longitude 8°18' East. The area has distinct wet and dry seasons. The rainfall pattern of the area is bimodal with peaks occurring in July to September.

The experiment was laid out in a Completely Randomized Design (CRD) under storage condition.

Treatments

The treatments used in the experiment were:

- Treatment one (T_1) Control
- Treatment two (T_2) 5 g River sand
- Treatment three (T_3) 5 g Pepper (*Capsicum* spp) dust
- Treatment four (T_4) 5 g Wood ash.

Treatment five (T_5) 5 g mineral oil (vegetable oil). Five treatments were used and replicated three times. Maize grain was used in all treatments. All the samples under treatments were weighed, and 5 g of each material was applied. The experiment lasted for four (4) weeks in 2014 and 2015, respectively.

Table 1. Details of Weight of Material used and Treatments Code

Treatment code	Weight of 100 grains of maize (g)	Weight of Treatment Materials (g)
T_1	50	Control
T_2	50	5 g River Sand
T_3	50	5 g Pepper Dust
T_4	50	5 g Wood Ash
T_5	50	5 g Mineral oil

g: grams, T: treatment

Source of materials

Wood ash was obtained from *Hymenocardia acida*, sourced at the School Forestry Department reserved botanical forest. Undamaged maize grain was obtained from the Department of Agronomy, Cross River University of Technology (CRUTECH).

Clean river sand was obtained from Ovonum river, Obubra. Mineral oil (vegetable oil) and dry pepper were also obtained from the Department of Agronomy, CRUTECH, Obubra campus, Nigeria.

Experimental procedures

One hundred (100) clean and undamaged seeds were collected, weighed and used per replication. The collected maize grains were disinfected by deep wetting in a water-salt solution, and dried for three (3) days for five (5) hours interval (from 9 am-2 pm) daily. The dried and disinfected maize grains were allowed to cool for 6 hours before they were put into a plastic container. All the plastic containers used in the experiment were labeled against each treatment in all the replications.

Clean river sand obtained from Ovonum River was air-dried at room temperature (22-23 °C) in the soil laboratory of CRUTECH for 5 days. The sand was ground into fine particles with the aid of a laboratory mortar and pestle, the particles were sieved using 2-mm sieve. Wood of *H. acida* was burnt and ash was collected.

The whole dry pepper was grinned into fine particles and re-ground until it was dust. 2 mL of mineral oil (vegetable oil) was mixed with one hundred (100) clean maize grains and allow under storage condition for the weevil to infest and lay eggs.

Data collection

Data were collected on population of the weevils in each individual treatment; the populations were counted and recorded. Counted populations were destroyed at the end of each reading.

Statistical analysis

All data were analyzed using the procedure for the analysis of variance (ANOVA) for Completely Randomized Design. Separation of means was done using the Fishers Least Significant Difference (f-LSD) at 0.05% probability level.

3. RESULTS

All the materials used in this experiment were weighed and recorded using standardized measuring instrument - sensitive scale, as presented in **Table 1**.

Table 2. Effect of Wood ash, River sand, Mineral oil, and dry Pepper dust on Population of weevil on maize grain after 2 and 4 weeks of storage 2014 Experiment

Weeks Of Storage (WOS)			
Treatment code	Treatment (g)	2 WOS	4WOS
T_1	Control	6.00	12.67
T_2	5 g River sand	3.33	6.33
T_3	5 g Pepper dust	2.67	4.67
T_4	5 g Wood ash	0.00	0.00
T_5	5 g Mineral oil	3.67	7.00

WOS = Weeks of Storage

Results obtained in **Table 2**, at 2 Weeks of Storage indicate that the application of wood ash from *Hymenocardia acida* to the adult weevil (*S. zeamais*), causes maximum protection of the grains against damage. No adult of *S. zeamais* was found in the treatment with wood ash, giving it an advantage over all other treatments (T_1, T_2, T_3, and T_5).

River sand at 5 g recorded a population mean of (3.33) which indicates a slow rate of control compared to the wood ash. Dry pepper (*Capsicum* spp) dust shows an increase in the control rate giving a mean value of 2.67, indicating the effect of pepper dust on the control of the pest. Mineral oil gave a mean value of insect population at 3.67, indicating that mineral oil is a weak protectant compared to the treatments T_3 and T_4, respectively. River sand and mineral oil were shown to have closely related ability to keep the grain weevil-free, giving a mean value of 3.33 and 3.67, respectively. At 4 Weeks of Storage, wood ash from *H. acida* still maintained its toxicity against the weevil, giving a mean value of (0.00) which indicated no weevil attack on the maize grain in the treatment, giving a significant protection over the control, with the control mean value of 12.67. Mineral oil at 5 g gave a weak protection at 4 Weeks of Storage, producing a population with a mean value of 7.00, which indicates a weak toxicity of the oil as a protectant. However, at 4 Weeks of Storage, pepper dust recorded a mean value of 4.67, reflecting the effectiveness of pepper as a protectant on grains of maize. River sand at 4 Weeks of Storage recorded a mean value of 6.33, indicating the presence of more weevil in the treatment, apart from the treatment five (T_5), and the control (T_1).

Table 3. Weight Loss in Maize grain After 4 Weeks of Storage
2014 Experiment

Treatment code	Weight of 100 grains After 4 Week of Storage (g)	Weight loss per treatment After 4 Week of Storage (g)
T_1	15.0	35.0
T_2	25.0	25.0
T_3	35.0	15.0
T_4	49.0	1.00
T_5	20.0	30.0

Grain weight loss was calculated by subtracting original weight from the final weight.
Thus, 50 g – 15 g = 35 g

The result obtained in 2014 experiment indicates the effectiveness of wood ash, pepper dust, river sand, and mineral oil as a protectant to physically control/reduce the increase in population of weevil in stored maize grain for the high food quality and human nutrition. However, the data presented in Table 2 agree with the finding of Jean *et al*. (2015) that reported the efficacy of wood ash for the control of insect pest in stored maize grain. The mortality recorded at the end of 4 weeks of storage was high in the pepper dust compared to mineral oil and river sand.

Table three (3) below, presents the weight of one hundred (100) grains of maize used per treatments at the end of four (4) Weeks of Storage. Weight loss per treatment during this period of four weeks of storage was also recorded.

Result obtained in **Table 3** indicate the effect of wood ash as the most effective treatment over all other treatments, since the weight loss was limited to only 1% in (T_4), this further emphases the work of Jean *et al*. (2015), that proves the efficacy of wood ash in controlling weevil of grains in storage.

Table 4. Effect of Wood ash, River sand, Mineral oil, and dry Pepper dust on Population of weevil on maize grain at 2 and 4 Weeks of storage 2015 Experiment

Weeks of Storage (WOS)			
Treatment code	Treatment (g)	2 WOS	4WOS
T_1	Control	6.00^a	12.67^a
T_2	5 g River sand	3.33^b	6.67^b
T_3	5 g Pepper dust	3.00^{bc}	4.33^c
T_4	5 g Wood ash	0.00^d	0.00^d
T_5	5 g Mineral oil	4.00^b	7.33^b

^{a}No protection, ^{b} medium protection, ^{c} medium/weak protection, ^{d} high protection against the weevil

Results obtained in **Table 4**, is similar to the Results presented in Table 2, the ANOVA analysis shows that Wood ash at 2WOS statistically produced the least grade (alphabet) with a mean value of (0.00) indicating zero population of the weevil, and further reflecting the efficacy of *H. acida* ash on the control of the pest over the control. At 2 Weeks of Storage, river sand recorded a mean value of 3.33, indicating an average potential of control, reflecting the point that river sand does not totally eradicate, but helps in reducing the population of insect pest that would have attacked the crop. Pepper dust at 4WOS recorded a mean value of 3.00, presenting pepper dust to be more effective than the river sand and to some extent the mineral oil. The value of 3.00, recorded statistically, shows an increase in the efficacy of pepper dust to be used as a protectant for grain storage in order to ensure a high food quality and human/animal nutrition. Mineral oil recorded a mean value of 4.00 at 2WOS over the control with a value of 6.00. This indicates the weak potential of mineral oil on the protective capacity on the grain compared to other treatments, except the control. However, it can be presented that the efficacy of Wood ash < dry Pepper dust < River sand < Mineral oil < control.

At 4 Weeks of Storage, wood ash still recorded a mean value of (0.00), presenting that there is no weevil attack on the stored grains. This shows 100% protective capacity over the control which recorded a mean value of 12.67. ANOVA analysis presented that Mineral oil followed the control in terms of weak protective capacity. Pepper dust at 4WOS recorded a mean value of 4.33, indicating a 1% increase compared to the value at 2Weeks of Storage. This indicates that the longer the pepper dust remains in storage, the weaker it may become in effectively controlling the weevil pest. River sand recorded a mean value of 6.67, indicating 50% of the value recorded in the control, presenting it as an average protectant on the maize grain. Treatments (T_2, T_3, T_4, and T_5) show an increase in the ability to protect the grains against weevil massive destruction over the control, which was massively destroyed by the pest, thereby reducing the quality of the produce.

The result obtained in the 2015 experiment is in consonance with the result of 2014 experiment, and therefore agrees with the finding of Kranz *et al*. (1977), who recorded reduction in the grain infestation/damage as a result of the application of river sand as a grain protectant. Application of various bio-substances have been used and recorded as protectant against the crop destruction, especially in storage. A further submission by Wolfson *et al*. (1991) present the wood ash as being more effective than most bio-substances used as the protectant in grain storage. This has been proved in the data presented in Table 2, and 4, indicating no weevil entrance, hence, no population of *S. zeamais* was recorded for wood ash treatment.

Table 5. Weight Loss in Maize grain After 4 Weeks of Storage
2015 Experiment

Treatment code	Weight of 100 grains After 4 Week of Storage (g)	Weight loss per treatment After 4 Week of Storage (g)
T_1	16.1	33.9
T_2	26.3	23.7
T_3	35.3	14.7
T_4	49.2	0.8
T_5	20.1	29.9

Grain weight loss was calculated by subtracting original weight from the final weight.
Thus, 50 g – 16.1 g = 33.9 g

Results obtained in **Table 5** indicate that the weight of 100 grains of maize was reduced at the end of 4 Weeks of Storage. This possible reduction in weight of maize could be attributed to the weight lost due to moisture reduction in the grain, as a result of storage time, reduction in volume. But principally, due to the infestation of *S. zeamais* feeding on the treated maize grain, this finding is in consonance with the submission of Adedire (2001).

4. DISCUSSION

Results obtained in the study indicate that river sand, dry pepper dust, wood ash, and mineral oil have the ability to physically protect maize grain against *S. zeamais* invasion. The treatments have been observed to be effective against over-population of the weevil. The control of *S. zeamais* population, using treatment (T_4) 5 g of wood ash from *H. acida* shows a high percentage of protection against the population settlement in the grain compared to any other treatment.

All treatments (T_2, T_3, T_4, and T_5) except (T_1) the control, gave a protective guide, preventing more eggs to be laid, and this leads to the reduction in the level of damage to the grains. Ofuya (1986); Wolfson *et al*. (1991); and Apuulu *et al*. (1996) reports are in line with this finding. Seed grains which harbors eggs or incubating larvae prior to, and during treatment, will be damaged, which could have accounted for damage done on the treated grains. Population of *S. zeamais* recorded in the treatments T_2, T_3, and T_5 were low and medium, the treatments were unable to kill the weevil within this period of time because it coincides with the period where more of *S. zeamais* eggs are laid (Dick and Credland, 1984).

The application of (T_4) 5 g of wood ash recorded no population of the pest, presenting it as effective, and acting as a physical barrier in preventing the adult *S. zeamais* from entrance into the grain and further reproduction (Wolfson *et al*., 1991). Population of the pest in treatment (T_2) 5 g of the river sand was also minimal and further total damage of the grains was reduced; this has also been reported by Kranz *et al*. (1977). Population of *S. zeamais*in treatment three (T_3) 5 g dry pepper dust was low, indicating the pepper dust potential in the control of the pest. Hence, all treatments except treatment one (T_1) the control, help to keep the population of *S. zeamais* low and therefore physically protected the grains.

Weight loss of maize grain in this experiment may be related to a reduction in weight of volume. However, a reduction in the weight may not be totally caused by the feeding effect, caused by the pest, but also by reduction in moisture content of the grain. But weight loss usually happens mostly by feeding-on by the pest in store. The weight loss in the maize grains due to *S. zeamais* population appearance is in consonance with the findings of Adedire (2001) that reported constraint in cultivation/storage of grains due to the pest attack.

The study have revealed that ash from *H. acida*, river sand, dry pepper dust, and mineral oil (vegetable oil) control/reduced weevil infestation and weight loss of the maize grain.

5. CONCLUSION

Results of the this investigation present the wood ash, river sand, mineral oil, and dry pepper dust as active against *S. zeamais* invasion during the maize grain storage. Analyzed results present wood ash from *H. acida* as having the most effective protectant ability over *S. zeamais* infestation. It could be concluded that 5 g of the treatments used in the study showed a potential of physically controlling (protect) maize grains against *S. zeamais* attack during storage, as its efficacy has been proven as positive and effective.

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