



Effects of charcoal and wood ash on *Trogoderma granarium* Evert (Khapra beetle) infesting stored groundnut seeds

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Abstract

The study was conducted to investigate the effectiveness of wood ash and charcoal in the control of *Trogoderma granarium* infesting groundnut. Charcoal and wood ash were separately admixed with 50g of groundnut seeds stored in ventilated plastic containers at the rates 0, 5, 10 and 15g respectively. Five unsexed adult *T. granarium* were introduced into the different treatments. Observation was taken on the mortality of adult beetle, number of emerged first filial progeny days after treatment, % weight loss of seeds and on the phytochemical analysis of wood ash and charcoal. Results revealed that both treatments were able to significantly ($P < 0.05$) suppress the population of *T. granarium* compared to the control. Also, 15g concentration level of the dust gave the best result in terms of adult mortality and progeny. Seeds treated with both wood ash and charcoal had a weight loss of 14.64 and 13.93% respectively when compared to untreated seeds which had 31.43%. Phytochemical analysis showed that charcoal contained lignin in high dose while wood ash contained potassium carbonate and oxide in moderate amount. The use of wood ash and charcoal can be further recommended for future control against *T. granarium* infesting stored groundnut.

Key words: Groundnut; *Trogoderma granarium*; wood ash; charcoal; pest control

Introduction

Groundnut is produced in over 100 countries in both the tropics and sub-tropical countries. China is the world's leading producer of groundnut with 40 percent of world's production, followed by India having 23 per cent, next, a group of Sub-Saharan African (SSA) countries with over 8.4 per cent and the United States producing about 5.6 per cent (Bajia *et al.*, 2016). Groundnut is an important subsistence food crop in the tropics. The seeds contain about 47-53% oil, 25-36% protein, 10-15% carbohydrate and they are also rich in phosphorus, vitamin B and vitamin E (Award *et al.*, 2000). Groundnut is used in many forms. It can be processed into groundnut oil, peanut butter, roasted or boiled and as condiments in food and soups. The cake gotten from groundnut after extracting oil from it can be further made into the popularly known groundnut cake called "kulikuli", especially in northern Nigeria where the name originated from (Atanda and Akano, 1990). Groundnut oil is the most important product of the crop. It has both domestic and industrial uses and about 75% of the world's production is used in the extraction of edible oils which is preferably used for cooking due to its mild flavour, and monounsaturated content, considered to be healthier than saturated oils and also resistant to rancidity (Bloomoff *et al.*, 2006).

Low productivity in groundnut is attributed to several constraints. Besides abiotic stresses, groundnut production is limited by insect pests, diseases and weeds. Insect pests represent a major yield constraint in groundnut by direct damage or as vectors of virus diseases both in the field and in storage (Bajia *et al.*, 2016). In Sudan, most of the stored insect pests occur throughout the humid areas in which *Sitophilus oryzae* (L.), *Sitotroga cerealella* (Olivier) are most common. In

the dry Northern and Eastern Sudan, on primary pest, *Trogoderma granarium* (Everts) are a dominant pest species especially on stored groundnut (Ibrahim, 2001). *T. granarium* is a serious pest of groundnut. It thrives in warm and dry climates although the population increases rapidly in a short period during hot and dry climatic conditions. They can also survive cooler climates when in warm situations inside storage products in warehouses (Ibrahim, 2001). Insect infestation causes dry mass loss and the reduction in quality of the product by perforations in the seeds of groundnuts by their feeding activities (Lale, 2002). In order to protect seeds from insect infestation, synthetic chemicals have been used, although effective, it poses health and environmental related concerns due to their toxic effects thereby leading to the intensive search for safer alternatives in the control of insect pest infesting groundnut in storage (Isman, 2006). Hence the initiation of this study, to investigate the effectiveness of charcoal and wood ash in the control of *T. granarium* in stored groundnut seeds.

Methods

Study location, source and preparation of seeds: The study was conducted in the Department of Crop Protection laboratory, Faculty of Agriculture, University of Ilorin, Ilorin. The phytochemical analysis was carried out in the Department of Chemistry laboratory, University of Ilorin, Ilorin, Kwara State. Two kilogram of groundnut seeds were purchased from a local market known as Oja Gboro market in Ilorin, Kwara State. Unhealthy seeds were separated from healthy ones by spreading seeds on a flat surface and visually detecting seeds that have been deformed and damaged. Thereafter, seeds were put in a polythene bag and then disinfected by storing in a refrigerator at -10°C for 7 days to incapacitate



any existing eggs, larvae or adult pests inside seeds (if any).

Insect culture: A culture of khapra beetle (*T. granarium* Everts) was cultured under ambient conditions of $30 \pm 2^\circ\text{C}$ and $68 \pm 3\%$ relative humidity in groundnut seeds stored in a rearing jar. Heterogenous population of *T. granarium* was obtained from the Nigerian Stored Product and Research Institute located, Ilorin, Kwara State.

Collection and preparation of charcoal and wood ash:

The woody parts of mango, shear butter, cashew and neem trees were obtained by cutting stems and bark with a sharp machete from trees around the premises of the Faculty of Agriculture, University of Ilorin. The collected woody parts were burnt completely aerobically after sun-drying to reduce its moisture content at increasing temperature in a laboratory electric furnace to get charcoal from it. The resulting charcoal gotten was allowed to cool down before being broken into smaller pieces which was sieved to get fine charcoal dust using sieves of different mesh sizes. Ash was obtained by further subjecting charcoal to combustion at elevated temperature in the electric furnace. The wood ash particles were shaken and sieved using various mesh sizes. This was to remove detrital materials and to get the finest particle size of wood ash according to the methods described by Pipi and Omodamiro (2014).

Experimental procedure: 50 grams of disinfested groundnut seeds were put into ventilated transparent plastic containers. An electric weighing scale was used to measure both the charcoal and the wood ash powder which was applied to seeds at different rates viz; 0 (control), 5, 10 and 15g. Next, groundnut seeds were

agitated in the container to promote the even spread of the treatment dust in it by using a wooden spatula to stir until evenly distributed. Ten freshly emerged unsexed adults of *T. granarium* were introduced from the stock culture into each of the treated and untreated containers using an aspirator to collect and transfer beetles from the stock culture into the various treatments to prevent damage of the insect. Containers were then covered with muslin cloth fastened with rubber band to allow for ventilation and to prevent escape of the insect.

Each treatment was replicated three times including the control to give a total of 24 experimental units. Observation for adult mortality was done by counting the number of the insect pest observed from 24 hours after treatment for a period of 10 days. Insects were confirmed dead when no response was gotten from them after slightly probing the abdomen with a sharp entomological needle. For the examination of first filial (F1) generation, forceps was used to pick 5 seeds at random from each replicates which was then examined for eggs and larvae by carefully dissecting seeds with a blade from 23 days after treatment. The experiment was carried out at ambient temperature of $30 \pm 2^\circ\text{C}$ and relative humidity of $68 \pm 2\%$.

Data analysis: Data collected were analysed by two-way analysis of variance (ANOVA) and significant different treatment means were separated according to New Duncan's Multiple Range Test at 5% probability level using IBM SPSS version 21. Seed samples were weighed using a weighing scale to get the initial and final weight expressed in percentage (%) using the following formula:

$$\text{Percentage weight loss} = \frac{\text{initial weight} - \text{final weight}}{\text{initial weight}} \times 100$$

Results

Effect of wood ash and charcoal on adult mortality of *T. granarium* on stored groundnut

Table 1 shows the effects of wood ash and charcoal on adult mortality of *T. granarium* on stored groundnut. Post hoc analysis revealed that there was significant difference between the treatment and the control. Stored groundnut seeds treated with wood ash and charcoal had varied mean numbers of dead adults that were significantly ($P < 0.05$) effective in reducing the population of the insect from 1 to 10 days after treatment (DAT) compared to control which was significantly lower ($P > 0.05$). Observation of the mean numbers showed that seeds treated with wood ash had the highest mean number of adult mortality of *T. granarium* from 1 to 10 DAT and was more potent in reducing the population of the insect pest in storage compared to seeds treated with charcoal. The control had no effects on the mortality of *T. granarium* adult as shown in Table 1.

Effect of wood ash and charcoal concentrations on the emergence of first filial progeny of *T. granarium* infesting stored groundnut seeds

Table 2 shows the effect of wood ash and charcoal concentrations on F1 progeny emergence of *T. granarium*. Result revealed that at 23 DAT the concentration rate of 10 and 15 grams were significantly ($P < 0.05$) able to suppress the emergence of *T. granarium* progeny (0.33) compared to 5g (2.00) and control (2.67) which had the highest. Though there was no significant difference between the various treatment levels from 25 to 35 DAT, observations of the mean numbers further revealed that there was a decrease in progeny emergence with the increase in level of the treatments with 15g having the least mean number of emergence from 25 to 33 DAT compared to the other concentrations (Table 2). The control rate had the highest mean number of progeny emergence of *T. granarium* as shown in Table 2. The concentration level of 15g



performed best in its ability to suppress *T. granarium* progeny.

Effect of wood ash and charcoal concentrations on adult mortality of *T. granarium* infesting stored groundnut seeds

Table 3 shows the effect of wood ash and charcoal concentrations on the mortality of *T. granarium* adult infesting stored groundnut seeds. There was a significant difference between the various concentrations and the control. Post hoc analysis revealed that the concentration level of 5, 10 and 15g was significantly ($P < 0.05$) effective in increasing the mortality of adult *T. granarium* from 2 to 9 DAT compared to the control which was had no adult mortality (Table 3). However, close observation of the mean showed that the concentration rate of 15g had the highest adult mortality rate from 1 to 9 DAT when compared to the others.

Effect of wood ash and charcoal treatment on the total weight loss of groundnut seeds after treatment

Table 4 shows the effect of wood ash and charcoal treatment on percentage weight loss of groundnut seeds after treatment. Result indicated that there was a significant difference between the treatment and the control. Observation revealed that groundnut seeds treated with both wood ash and charcoal had the percentage weight loss of 14.64 and 13.93% respectively which were significantly ($P < 0.05$) lower compared to the control which had a weight loss of 32.43% as shown in Table 4.

Phytochemical composition of charcoal and wood ash

Table 5 shows the phytochemical composition for both charcoal and wood ash. Phytochemical analysis of charcoal revealed that lignin was present in high concentrations while Helocelluloses was also detected but in a very small concentration. Also, the phytochemicals detected in wood ash were potassium carbonate and oxide which were both indicated to be in moderate amount (Table 5).

The investigations revealed that both charcoal and wood ash have insecticidal potentials in the control of *T. granarium* infesting stored groundnut seeds. The toxic effect of charcoal against the insect pest was slower in comparison to wood ash which was faster and caused more mortality. The insecticidal effect increased with ascending levels of concentration for both the charcoal and the wood ash. Mewis and Ulrich (2001) had reported that ash served as an insecticidal property that significantly reduced the survival of adult *Tribolium castaneum* and *Tribolium molitor* after fourteen days of exposure. The present work showed similar insecticidal potency of wood ash in the control of *T. granarium* on stored groundnut seeds. Wood ash and charcoal evoked increased mortality rate of the insect pest in increasing concentrations over time. The same activity was recorded by Demissie *et al.* (2008) using commercial diatomaceous earth (DE) formulations against *S. zeamais*. Also, the exposure time was crucial in the effectiveness of wood

ash and charcoal because insects' movement increases the contact of the cuticle with dust particles. The mortality of insects caused by wood ash and charcoal could be attributed to the gradual dehydration initiated by the abrasiveness of the small particles of the dust and by the absorption of available oils in the body of the insect pest, the dust also acts on the layer of wax on the epicuticle of the insect, promoting the fatal loss of moisture. Wood ash and charcoal also caused mortality of *T. granarium* by desiccating the cuticle and provoking the suffocation of the insect (Subramanyam and Roesli, 2000).

The increase of mortality rate of *T. granarium* after being treated with wood ash and charcoal may be also due to the presence of the phytochemicals contained in them. Charcoal contained high content of lignin which has been reported by Khanam *et al.* (2006) to be effective against *T. castaneum*, *T. confusum* and *S. oryzae*, although, he reported that it was not effective against storage pest like *C. maculatus*, this work revealed its toxic effect against *T. granarium* infesting stored groundnut seeds. Wood ash also contained potassium carbonate in moderate amount which was also investigated by Geoffrey (2014) to have strong effect in the reduction of insect pest affecting beans pod. This is in conformity to the present work in its insecticidal effect against *T. granarium* on groundnut. Wood ash and charcoal served as bio pesticide in this study. Bio pesticides have been used as an effective means of pest control. Unlike chemical insecticides, bio pesticides easily break down and pose no deleterious risk of residues in crops making them a suitable alternative to chemicals and therefore play an important role in integrated pest management (Gašić *et al.*, 2013; Degri *et al.*, 2013) as corroborated in this study.

Conclusion

Wood ash and charcoal being a natural product with good insecticidal potential in serving as alternatives to synthetic insecticides in the control of *T. granarium*. The efficiency of both wood ash and charcoal being a natural product and also environmentally friendly, could be further exploited for future integrated pest management in the control of destructive pests of stored grains. Therefore, a recommendation for adoption is advisable.

Conflict of interest

The authors declare that they have no conflict of interest.

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Table 1: Comparative effect of wood ash and charcoal on adult mortality of *T. granarium* on stored groundnut

Treatment	Days after treatment (DAT)									
	1	2	3	4	5	6	7	8	9	10
Wood ash	1.22 ^a	2.56 ^a	3.44 ^a	4.11 ^a	5.11 ^a	6.00 ^a	6.56 ^a	7.33 ^a	8.56 ^a	9.78 ^a
Charcoal	0.89 ^a	1.78 ^a	2.78 ^a	3.78 ^a	5.00 ^a	5.78 ^a	7.00 ^a	8.00 ^a	8.89 ^a	6.33 ^b
Control	0.00 ^b	0.00 ^c	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b	0.00 ^b
SEM	0.19	0.22	0.24	0.19	0.23	0.23	0.23	0.25	0.19	0.92

Values with the same superscript in the same column are not significantly different from each other at $P \leq 0.05$ according to New Duncan's Multiple Range Test. SEM = standard error of mean



Table 2: Concentration effect of charcoal and wood ash on F1 progeny emergence of *T. granarium*

Conc.(g)	Days after treatment (DAT)						
	23	25	27	29	31	33	35
5	2.00 ^a	3.00 ^{ab}	2.33 ^a	3.67 ^{ab}	4.67 ^a	3.33 ^a	1.00 ^a
10	0.33 ^b	3.00 ^{ab}	3.33 ^a	2.67 ^b	3.33 ^a	1.33 ^a	0.00 ^{ab}
15	0.33 ^b	1.33 ^b	2.00 ^a	2.00 ^b	2.67 ^a	0.33 ^a	0.00 ^{ab}
0	2.67 ^a	4.33 ^a	4.33 ^a	6.00 ^a	4.00 ^a	2.00 ^a	0.00 ^{ab}
SEM	0.41	0.62	0.82	0.80	0.76	0.87	0.23

Values with the same superscript in the same column are not significantly different from each other at $P \leq 0.05$ according to New Duncan's Multiple Range Test. SEM = standard error of mean

Table 3: Effect of wood ash and charcoal concentrations on adult mortality of *T. granarium*

Conc. (g)	Days after treatment (DAT)								
	1	2	3	4	5	6	7	8	9
5	0.50 ^{bc}	1.83 ^a	2.67 ^b	3.67 ^a	4.33 ^{ab}	5.33 ^{ab}	6.33 ^a	7.33 ^a	8.67 ^a
10	1.00 ^{ab}	2.00 ^a	3.00 ^{ab}	3.67 ^a	5.00 ^{ab}	5.83 ^{ab}	6.83 ^a	7.67 ^a	8.00 ^a
15	1.67 ^a	2.67 ^a	3.67 ^a	4.50 ^a	5.83 ^a	6.50 ^a	7.17 ^a	8.00 ^a	9.00 ^a
0	0.00 ^c	0.00 ^b	0.00 ^c	0.00 ^b	0.00 ^c	0.00 ^c	0.00 ^b	0.00 ^b	0.00 ^b
SEM	0.24	0.27	0.29	0.23	0.28	0.28	0.27	0.30	0.23

Values with the same superscript in the same column are not significantly different from each other at $P \leq 0.05$ according to New Duncan's Multiple Range Test. SEM = standard error of mean

Table 4: Effect of wood ash and charcoal on the weight of stored groundnut after treatment

Treatment	% Weight loss
Wood ash	14.64 ^a
Charcoal	13.93 ^a
Control	31.43 ^b
SEM	1.05

Values with the same superscript in the same column are not significantly different from each other at $P \leq 0.05$ according to New Duncan's Multiple Range Test. SEM = standard error of mean

Table 5: Phytochemical composition of charcoal and wood ash

Phytochemicals	Charcoal	Wood ash
Lignin	***	-
Helocelluloses	*	-
Potassium carbonate	-	**
Oxide	-	**

Key: *** = present in high concentration, ** = present in moderate concentration, * = present in very small concentration - = not detected