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Studies on the Efficacy of Cow Dung Ash against Maize Weevil, *Sitophilus zeamais* Motsch. (Coleoptera: Curculionidae)

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Abstract

Experiments were carried out to assess the protectant ability of cow dung ash (CDA) to maize grains against Sitophilus zeamais Motsch. under laboratory conditions of 28-32°C and 60-75% relative humidity (R.H.). The CDA at different doses of 0.625, 1.25, 2.50, 5.00, 10.00% (w/w) were used and permethrin powder at 0.625% used as positive control, negative control were also set up in different Petri dishes to which no permethrin or ashes were added. Five pairs of weevils were introduced into each of the Petri dishes and covered with muslin cloth. The experiment was arranged in a completely randomized design (CRD) and replicated three times. Effect of the treatments on adult mortality was determined. Adult emergence and weight losses in seeds treated with CDA at different doses were also assessed. Findings of the study revealed that the adult mortality of S. zeamais among different CDA doses differed significantly (p < 0.05) and ranged from 13.33 to 100.00% at 96 hours after treatment (HAT). Results of the study also showed that LD_{50} of CDA against S. zeamais at 24 hours after treatment (HAT) was 4.57 % (w/w). There were no F_1 adult emergences of S. zeamais in all the treatments. Weight losses were found to differ significantly (P<0.05) which were observed in grains treated with the lowest dose and the control only. It was found that CDA had no adverse effect on the germination of maize. There is therefore the need to identify the bioactive compounds in CDA that are responsible for its insecticidal ability against S. zeamais.

***Key words:** Adult emergence, Cow dung ash (CDA), Germination capacity, Mortality, Grain damage, Sitophilus zeamais*

INTRODUCTION

Maize as an integral component of staples in Sub-Saharan Africa (SSA) is considered as an essential source of income for farmers. It is well known to be one of the few crops that have profound effects on the livelihoods of people in Sub-Saharan Africa (Akowuah *et al*., 2018). Maize is usually stored to provide food reserves and seed materials for planting. It is one of the most popular crop plants all over the world, grown in over 140 million hectares all over the world (Onuminya *et al*., 2018). Maize is the first most important source of human dietary protein and the second most important source of calories after cassava and before beans. It supplies about 20% of global food calories (Olorunmota *et al*., 2021).

Sitophilus zeamais is the most devastating storage pest of maize, causing serious management problem facing agriculture in developing countries (Abulude *et al*., 2007). The grain damage caused by *S. zeamais* to cereal crops prompted researchers to investigate more on controlling strategies of the weevils in cereal grains (Goftishu and Belete, 2014; Khaliq *et al*., 2015; Cosmas *et al*., 2018; Suleiman, *et al*,. 2021).

Synthetic insecticides may play a significant role in reducing storage losses due to insect pests. However, the extensive use of these chemicals poses so many problems such as insecticide resistance, health risk to consumers and environmental contamination (Suleiman, 2019). These problems have necessitated the replacement of synthetic insecticides with natural products which are eco-friendly to protect stored grains from insect infestations (Vanmathi *et al*., 2012).

Natural products have been used for many years by small scale farmers in many parts of Africa to protects stored products (Suleiman and Rugumamu, 2017; Suleiman *et al*., 2019).

Previous findings demonstrated the use of these materials as safe and effective protectants of stored maize against *S. zeamais* infestations (Suleiman *et al*., 2018). These products act by suffocating the insect, restricting oviposition or even lead to the death of the insect (Sani and Suleiman, 2017; Suleiman *et al*., 2019).

In order to minimize the use of chemicals there is need for a search of alternative eco-friendly methods such as application of natural products like cow dung ash (CDA). Therefore, this study was aimed at evaluating the efficacy of CDA in controlling *S. zeamais* infesting stored maize.

MATERIALS AND METHODS

Rearing of *S. zeamais*

Adults of *S. zeamais* were obtained from infested maize sold in Charanchi market, Katsina State. Maize grains used for the rearing were brought from the aforementioned market and kept in an oven at 40ºC for 4 hours to disinfest the seeds and allowed to cool for 24 hours. Fifty pairs of adult *S. zeamais* were placed in 500 ml volume glass bottle containing 250 g of the disinfested maize grains. The set up was kept on the laboratory shelf at room temperature. The parent weevils were removed by sieving after 7 days of their introduction. Grains were kept under laboratory condition until emergence of F_1 progeny (Sani and Suleiman, 2017).

Collection and Preparation of CDA

Cow dung was collected from bushes around Tama village of Katsina, Nigeria. The cow dung was sun-dried and crushed into small particles. The small sized particles were placed in the muffle furnace and heated for 3 hours. The ash collected was allowed to cool and then stored in air-tight container under prevailing laboratory condition of 60-75% R.H and 28-32ºC (Suleiman and Haruna, 2020).

Assessment of Adult Mortality of *S. zeamais*

Procedure for determination of adult mortality adopted by Suleiman and Haruna (2020) was followed. Twenty grams (20 g) of healthy disinfested maize grains were placed in Petri dishes and treated with 0.125, 0.25, 0.50, 1.00 and 2.00 g of cow dung ash, separately. This was equivalent to 0.625, 1.25, 2.50, 5.0 and 10.0% (w/w), respectively. Permethrin (0.625%) was added to another 20 g seeds and another Petri dishes were also used which no powder permethrin was added. Ten newly emerged adult weevils were introduced to each of the treated and untreated grains in the Petri dishes which were then covered with muslin cloth and held in place with rubber hands. The set up was arranged in a completely randomized design (CRD) with three replications. This was inspected daily to remove, count and record dead insects for four days. At the end of the observation period, all weevils (dead and alive) were removed and percentage adult mortality was determined as:

$$\text{Mortality (\%)} = (\text{Number of Dead Weevils})/(\text{Total Number of Weevil})\ \text{X}\ 100$$

Determination of Lethal Dose (LD_{50}) of CDA

Lethal dose (LD_{50}) was evaluated following the methods of Ebadollahi and Mahboubi (2011). The number of dead weevils in each bottle containing maize grains treated with the CDA was counted at the end of 24 hours after treatment HAT). The LD_{50} was calculated by using probit analysis with SPSS (version 16.0) software package.

Examination of Adult Emergence of *S. zeamais*

The remaining weevils (dead and alive) were sieved from the treated maize grains immediately after the mortality test. The grains were left undisturbed under laboratory condition for 35 days to observe for F_1 adult emergence of the weevils. To calculate the adult emergence direct examination was performed daily from the first emergence for seven days. All emerged individuals were removed, counted and recorded (Suleiman *et al*., 2019).

Assessment of Grain Damage

Both treated and untreated grains were sieved to remove the ash and any dust. Grain damage and weight losses were determined using the procedure of Suleiman and Haruna (2020):

$$\text{Weight Loss (\%)} = (\text{Initial Weight (g)} - \text{Final Weight (g)})/(\text{Initial Weight (g)})\ \text{x}\ 100$$

Seed Viability (Germination) Test

Treated and untreated maize grains were kept for additional 3 months after completion of the emergence of F_1 progeny. Five seeds were randomly selected from each of the treatments and placed on moist Whatman No. 1 filter paper in disposable Petri dishes. The Petri dishes were kept in an incubator for seven days, after which emerged seedlings were counted and per cent viability was calculated following Ileke and Oni (2011):

$$\text{Viability (\%)} = (\text{Number of Germinated Seeds})/(\text{Total Number of Seeds Planted})\ \text{X}\ 100$$

Data Analysis

All data were tested for normality using KS normality test and found to be non-parametric. For this reason, Kruskal-Wallis test was employed to test if there was significant difference in the effects of CDA on adult mortality, weight losses and seed viability in the treated grains. Significantly different means were separated using Dunn's multiple comparison tests. All analyses were performed at $p < 0.05$ level of significance.

RESULTS

Adult Mortality of *S. zeamais* Exposed to CDA

Adult mortality of *S. zeamais* in maize grains treated with different concentration of CDA varied. The mortalities were directly proportional to the varying concentrations of CDA applied and ranged from 13.33 to 66.67%, 53.33 to 96.67%, 83.88 to 100.00% and 93.33 to 100.00% among the treatments at 24, 48, 72 and 96 hours after treatment (HAT), respectively (Table 1). No adult mortality of *S. zeamais* was observed in the untreated maize grains during the study period. Kruskal-Wallis test showed the existence of significant difference ($p < 0.05$) in adult mortality of *S. zeamais* among various concentrations of CDA, permethrin and control at 24, 48, 72 and 96 HAT. However, the significant difference that existed at 96 HAT was only between the treatments and the control. Mortalities in CDA treated maize were statistically similar as indicated by Dunn's comparison test (Table 1). The mortalities also increased with increase in exposure periods in the following order: 24 < 48 < 72 < 96 HAT.

Table 1: Mean Adult Mortality of *S. zeamais* in Maize Grains Treated with Varying Doses of CDA after Different Exposure Periods

Dose (%)	Mean Adult Mortality of *S. zeamais* (% ± S. E.)			
	Exposure Period (Hours)			
	24	48	72	96
0.625	13.3 ± 3.33^{d}	53.33 ± 3.33^{c}	83.33 ± 3.33^{b}	93.33 ± 3.33^{a}
1.25	26.67 ± 3.33^{c}	66.67 ± 3.33^{c}	86.67 ± 3.33^{b}	100.00 ± 0.00^{a}
2.5	36.67 ± 3.33^{c}	76.67 ± 3.33^{b}	90.00 ± 0.00^{b}	100.00 ± 0.00^{a}
5.0	46.67 ± 3.33^{b}	90.00 ± 0.00^{a}	96.67 ± 3.33^{a}	100.00 ± 0.00^{a}
10.0	66.67 ± 3.33^{a}	96.67 ± 3.33^{a}	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}
Permethrin (0.625%)	76.67 ± 3.33^{a}	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}
Control (0.00%)	0.00 ± 0.00^{e}	0.00 ± 0.00^{d}	0.00 ± 0.00^{c}	0.00 ± 0.00^{b}

Values with different superscripts on the same column are significantly different at $p < 0.05$

Median Lethal Dose (LD_{50}) of CDA against *S. zeamais*

Median lethal dose (LD_{50}) of CDA against *S. zeamais* at 24 hours after treatment was 4.57% (w/w) with confidence limits (Cl) of 3.51 – 18.75% (Table 2). The Chi-square (X^2) goodness of fit showed that the difference was not significant ($p > 0.05$) for LD_{50} of CDA.

Table 2: LD_{50} of CDA against Adult *S. zeamais* at 24 HAE in Maize Grains

LD_{50} (%)	95% Confidence Limits		Slope ± S. E.	X^2	*P*
	Lower	Upper			
4.57	3.51	18.75	2.59 ± 0.12	2.325	0.763

Adult Emergence of *S. zeamais* in Treated Maize Grains

No adult emergence of *S. zeamais* was observed from all the treated samples within 35 days. However, the mean number of emerged adult beetles from untreated seeds was recorded as 39.00.

Weight Losses in Maize Grains Treated with CDA

The only weight loss (0.62%) observed among the treated maize grains was in those treated with the 0.625% concentration of CDA, while the untreated seeds lost 16.47% of their weight to *S. zeamais* (Figure 1). Kruskal Wallis test showed that there was significant difference ($KW = 18.792$; $p = 0.0036$) in weight losses of maize grains treated with cow dung ash at different doses.

Percentage Germination of Infested Maize with CDA

Germination of maize treated with CDA at 0.625, 1.25, 2.5, 5.0 and 10.0% varied. Result shows that the highest (100.00%) germination among the treatments was recorded in maize treated with 10.0% CDA while the lowest (46.67%) was observed in 0.625% CDA (Figure 2). The result also indicated that 60.00% of maize treated with permethrin at 0.625% germinated, while the control had 13.33% seed germination capacity (Figure 2). The germination capacity of maize was significantly different ($p < 0.05$) among varying doses of CDA and permethrin.

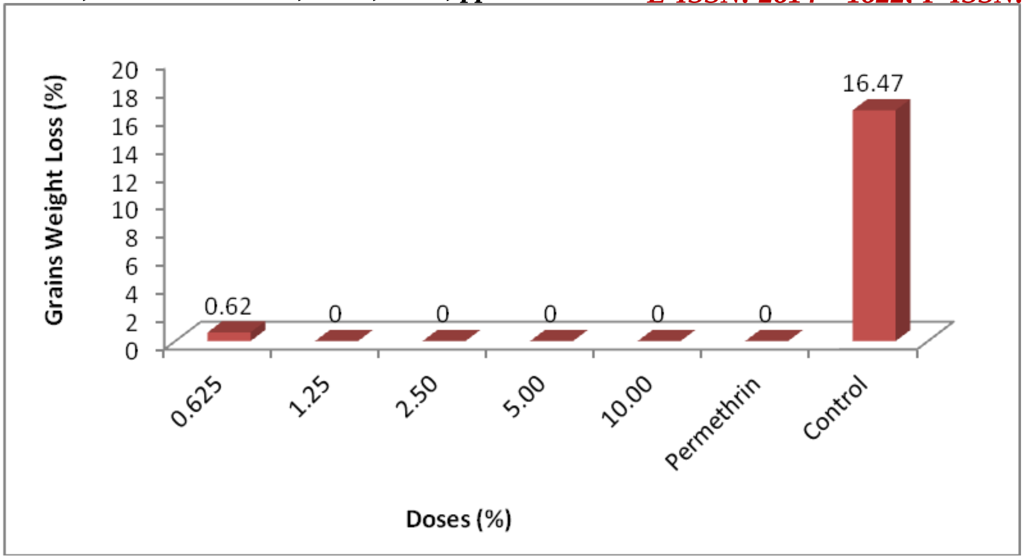

Figure 1: Weight Losses Caused by *S. zeamais* in Maize Grains Treated with Varying Doses of CDA

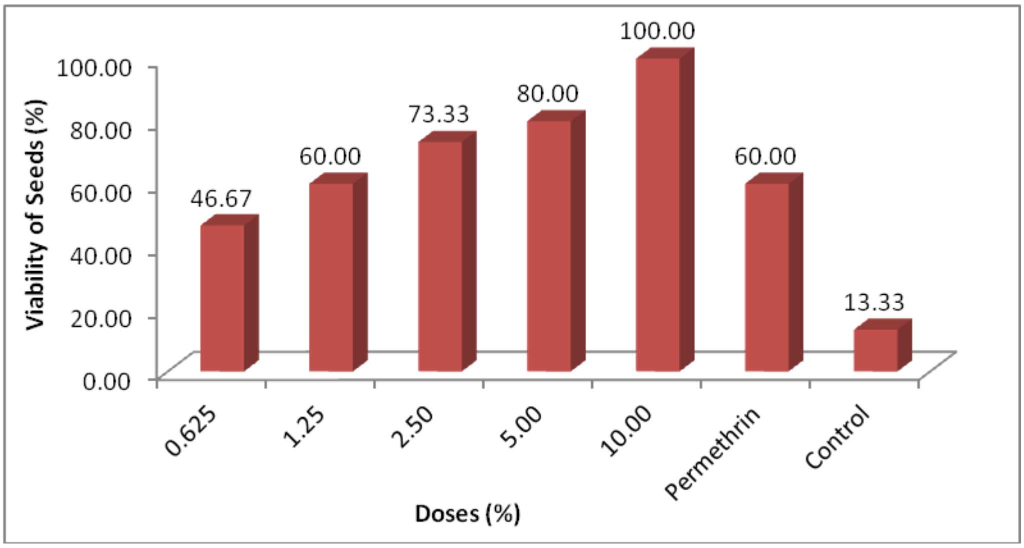

Figure 2: Seed Viability in Maize Treated with Varying Doses of CDA

DISCUSSION

Findings of this study have revealed that CDA was effective in causing high adult mortality of *S. zeamais*. This agrees with Arya and Tiwari (2013) who reported that cow dung ash applied at 2% to wheat grains resulted in 90.80% adult mortality of *Rhyzopertha dominica* Fab. Similar findings were reported by Narayana *et al.* (2019) that 2% CDA applied to maize grains caused 93.89% adult mortality of *R. dominica* at 24 HAT. Further, Suleiman and Haruna reported the effectiveness of 5% CDA in causing 100% adult mortality of *C. maculatus* at 96 HAT. It was also observed that the higher doses of CDA were almost as effective as permethrin in killing adults of *S. zeamais* concurring Suleiman and Haruna (2020). The killing effect of CDA could be as a result of their small-sized particles that might have blocked the insect spiracle leading to impaired respiration and eventual death as observed by others (Suleiman and Haruna, 2020).

Findings of this study indicated that the CDA was effective in reducing adult emergence of *S. zeamais*, implying that cow dung ash has a great protectant property against adult emergence of the insect. This is in agreement with Suleiman and Haruna (2020) who reported non emergence of *C. maculatus* in cowpea seeds treated with CDA. Arya and Tiwari (2013) reported that only 2.75 adults of *R. dominica* emerged in grains treated with CDA. Similar findings were reported by Adebayo and Ibikunle (2014) that 1 g of CDA applied to maize grains reduce adult emergence of *S. zeamais*. Furthermore, results of this study showed that the higher doses of cow dung ash applied were as effective as permethrin in reducing adult *S. zeamais*.

Finding of this study indicated that CDA did not allow *S. zeamais* to cause any damage in maize grains. This is line with the findings of Narayana (2019) which showed that only 0.19% of weight loss was recorded in maize grains treated with 2% CDA and infested by *R dominica*. Similarly, Tesema *et al*. (2015) reported that 2% of CDA gave a complete protection to chickpea against *C. chinensis*. Suleiman and Haruna (2020) also reported that application of CDA at various doses gave a complete protection to cowpea seeds against *C. maculatus*. The protection might be due to the insecticidal activity of CDA by resulting in high adult mortality and non emergence of the weevils from the treated grains, leading to reduced levels of infestation and weight losses.

Cow dung ash (CDA) did not significantly inhibit seed germination of maize. This is in conformity with Rani and Devanand (2011) who observed complete (100%) seed germination of maize treated with methanolic folia extracts of *Coccinia indica* L. and infested with *S. zeamais*, while no germination was recorded in the infested untreated control. The germination test in this study demonstrated that the botanicals did not show any adverse effects on germination capacity of the seeds. Also botanical powders of *T. minuta*, *D. stramonium* and *C. schimperi* did not hinder germination of sorghum after 84 days of storage (Yeshaneh, 2015).

The present study has revealed that there was increase in seed viability with increase in CDA concentration, which is consistent with the findings of Rani and Devanand (2011) who established that there was an increase in seed germination of maize grains treated with leaf extracts of *Carica papaya* L., *Coccinia indica* Weight and Arn, *Moordica charantia* L. and *Solanum melongena* L. with increase in concentration. The ability of the CDA to preserve seed viability could probably be attributed to their inhibitory actions on the incidence of seed borne fungi that could have killed the embryo of the seeds (G/selase and Getu, 2009).

CONCLUSION

Findings of this study demonstrated that the CDA tested possess insecticidal properties that could be applied in the control of *S. zeamais* in stored maize to the same level with the synthetic insecticides which are expensive and environmentally less friendly. It could also be concluded that CDA had effectively reduced weight losses, had no adverse effect on germination of maize. Therefore, CDA could be utilized to complement the integrated pest management (IPM) strategies of *S. zeamais*.

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