Efficacy of food-grade diatomaceous earth as grain protection against *Rhyzopertha dominica* - lesser grain borer in stored chickpea under tropical conditions

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Introduction

Insects are the major cause of the storage losses in grains [1]. According to recent studies, the loss of grains during storage under conventional warehousing circumstances in Sri Lanka, like in other tropical nations, is about 4-6 %, with insect attacks accounting for 80 % of the total. DEs are inert dust by origin and consist of the fossils of phytoplankton (diatoms) which are mainly composed of amorphous hydrated silicates [2]. When insects come into contact with the DE particles, the waxy fat and lipids are absorbed from their cuticles, resulting in water loss dehydration, and death [3]. DEs are of extremely low toxicity to mammals [4]. The lesser grain borer is a serious pest of stored grain worldwide [5]. Several reports showed that the lesser grain borer can be controlled using DE [6]. However according to Stathers et al, (2002) the main problem limiting their use as a grain protectant is the lack of information on their efficacy under smallholder farming conditions [5]. Thus, there is a need to assess the efficacy of the food-grade DE for the controlling of insect pests in pulses. The efficacy of the food-grade DE will be assessed on chickpeas for up to 9 weeks during the 2021 grain storage season from March to May. Farmers find it difficult to store these grains since they are highly susceptible to insect storage pests. Determination of the most appropriate application rates and the residual protection offered by these DEs is also important.

Methodology

Location. The experiment was conducted in Department of Agricultural Engineering, Faculty of Agriculture, University of Jaffna from March to May.

Grain selection. Five kilograms of commercially harvested chickpea, were obtained from the local market of Jaffna, Sri Lanka.

Storage facility. 100 g of grain were placed into glass granary jars of 250 ml capacity separately. The escape of introduced lesser grain borer was controlled by muslin cloth cover in the top of granaries. Granaries were stored on the raised platform, so as to prevent spoiling of grain through moisture movement from the floor.

Grain treatment. The five treatments (T1 (0.01%), T2 (0.05%), T3 (0.1%), T4 (0.5%), T5 (1%) and control (untreated samples)) were set based on different concentration of DE on mass weight basis with one untreated sample as a control.

Experimental design. A randomized complete design (CRD) with three replicates were used in the trial. Allocation of treatments to jars were randomized within blocks to eliminate bias and to ensure that there was an independent observation. Altogether 18 jars were used.

Species introduction. Twenty individuals of each tested same-aged unsexed species (*Rhyzopertha dominica*) were separately inserted into each granary jar.

Sample analysis. Since species introduction to every 7days interval till 5th weekend all samples were sieved (No. 10 laboratory sieve) to determine the number of dead and live insects. Manual counting was done to determine sample populations of dead and live insects with the help of forceps and a tally counter. After the 5th weekend onwards, the samples were let to progeny development

without any disturbance. The number of live and dead adult progenies (F1) were counted 9th weekend. The weight reduction of grain was measured by using a weighing balance after removal of all dead and live insects and all inert matter in each time interval.

Data analysis. MS Excel was used for data entry and summarizing the required variable. Data were analyzed using the SAS statistical package (university version). An Analysis of Variance (ANOVA) was carried out to determine if there are any significant differences between the treatment means.

Results and Discussion

There is proven evidence that DE was one of the successful products to control the storage pest in different types of commodities. As shown in Table 1, compared with control, 1% concentration shows a high % of mortality and a very little percentage of grain weight reduction. While other concentrations also show some percentage of mortality and reduced in grain weight reduction compared with control. For the 1% concentrations, the maximum cumulative % of mortality (100%) was attained within 3 weeks exposure time for DE.

Table 1. Mortality percentage of *Rhyzopertha dominica* and weight reduction of chickpea commodity with time.

Time interval		**Control**	**T_1 (0.01%)**	**T_2 (0.05%)**	**T_3 (0.1%)**	**T_4 (0.5%)**	**T_5 (1%)**
1st week	Mortality percentage (%)	0.00%^{d}	0.00%^{d}	1.67% ± (2.89)^{d}	20% ± (5)^{c}	28.33% ± (2.89)^{b}	55% ± (5)^{a}
	Cumulative mortality percentage (%)	0.00%	0.00%	1.67%	20.00%	28.33%	55.00%
	Grain weight reduction (%)	4.03% ± (0.05)	2.87% ± (0.07)	2.05% ± (0.14)	1.78% ± (0.04)	1.64% ± (0.06)	0.85% ± (0.09)
2nd week	Mortality percentage (%)	0.00%^{e}	11.67% ± (2.89)^{d}	18.33% ± (2.89)^{c}	26.67% ± (2.89)^{b}	45% ± (5)^{a}	41.67% ± (2.89)^{a}
	Cumulative mortality percentage (%)	0.00%	11.67%	20.00%	46.67%	73.33%	96.67%
	Grain weight reduction (%)	4.85% ± (0.04)	1.95% ± (0.24)	1.87% ± (0.14)	1.02% ± (0.07)	0.45% ± (0.04)	0.09% ± (0.05)
3rd week	Mortality percentage (%)	1.67% ± (2.89)^{d}	15% ± (5)^{c}	28.33% ± (5.77)^{b}	41.67% ± (5.77)^{a}	18.33% ± (2.89)^{c}	3.33% ± (5.77)^{d}
	Cumulative mortality percentage (%)	1.67%	26.67%	48.33%	88.33%	91.67%	100.00%
	Grain weight reduction (%)	3.98% ± (0.17)	1.03% ± (0.09)	0.52% ± (0.07)	0.21% ± (0.04)	0.09% ± (0.04)	0.00%
4th week	Mortality percentage (%)	0.00%^{b}	8.33% ± (2.89)^{a}	8.33% ± (2.89)^{a}	3.33% ± (2.89)^{b}	1.67% ± (2.89)^{b}	0.00%^{b}
	Cumulative mortality percentage (%)	1.67%	35.00%	56.67%	91.67%	93.33%	100.00%
	Grain weight reduction (%)	4.23% ± (0.07)	0.94% ± (0.03)	0.23% ± (0.03)	0.17% ± (0.08)	0.06% ± (0.09)	0.00%
5th week	Mortality percentage (%)	3.33% ± (2.89)^{a}	1.67% ± (2.89)^{a}	3.33% ± (2.89)^{a}	0.00%^{a}	1.67% ± (2.89)^{a}	0.00%^{a}
	Cumulative mortality percentage (%)	5.00%	36.67%	60.00%	91.67%	95.00%	100.00%
	Grain weight reduction (%)	3.95% ± (0.10)	0.51% ± (0.07)	0.20% ± (0.14)	0.10% ± (0.08)	0.05%± (0.05)	0.00%

Means bearing the same simple letter within the row are not significantly different at 95% confidence level or alpha $P<0.05$.

After 9 weeks of exposure to different concentrations of DE, the chickpea commodity treated with 1% and 0.5% concentrations of DE shows the zero number of pupal stage and F1 adult progeny of *Rhyzopertha dominica* species. At the same time, chickpea commodity treated with 0.1% concentration of DE shows the dead F1 generation of *Rhyzopertha dominica* species. This means, the larva has emerged as adults but at the end of 9 weeks, exposure period F1 progenies are completely suppressed. Also, progeny production notably reduced in the 0.05% of DE concentrated chickpea commodity. Likewise, progeny production in the 0.01% of DE concentrated chickpea commodity was decreased almost two times compared with control.

Conclusion

After 5 weeks of exposure time, the 1%, 0.5% and 0.1% of DE concentrated commodities shows the almost similar % mortality of *Rhyzopertha dominica* species, but the maximum % of mortality *Rhyzopertha dominica* species were attained at early in 1% of DE concentrated chickpea commodity within 3 weeks comparing with other two concentrations (0.5% and 0.1%). Hence, to control the *Rhyzopertha dominica* species by using concentrations of DE as 0.5% and 0.1% need a longer exposure time. For the concentration of 0.05% and 0.01% of DE the maximum mortality percentages of *Rhyzopertha dominica* species were 60% and 36.67% respectively. When comparing the total weight reduction percentages of chickpea commodities with different concentrations of DE, the highest concentrated chickpea commodity shows less weight reduction. When considering the progeny development (F1 generation), there was no visible larval stage or pupal stage, or mature adult of *Rhyzopertha dominica* species observed in the 1% and 0.5% concentrated chickpea commodity. Even though, the larva has emerged as adults in 0.1% of DE concentrated chickpea commodity, but at the end of the experiment there was no living F1 generation observed. From this study. it can be concluded that the different concentrations of DE significantly ($P<0.05\%$) influence the control of *Rhyzopertha dominica* species in chickpea commodities.

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