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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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Abstract – The efficacy of different concentrations of diatomaceous earth against the *Rhyzopertha dominica* in chickpea was evaluated. The selected concentrations were 0.01%, 0.05%, 0.1%, 0.5%, and 1% on (W/W) basis. Each treatment was replicated three times and 20 same-aged unsexed adult *Rhyzopertha dominica* species were introduced into each jar. The percentage of mortality *Rhyzopertha dominica* species and weight reduction of chickpea commodity were recorded weekly for five weeks. After the 5th week onwards the samples were let to progeny development without any disturbance. The progeny counts were carried out at the end of the 9th week. The results showed that mortality percentage *Rhyzopertha dominica* species, weight reduction of chickpea commodity, and progeny emergence highly affected by different concentrations of diatomaceous earth (DE). The maximum percentage of mortality was attained early, when the concentration was 1%, at the end of the 3rd week (100%). The percentage of weight reduction is relatively less for 1% concentration compared with other treatments. After 9 weeks of exposure, the chickpea commodity treated with 1% and 0.5% concentrations of DE shows the zero number of visible pupal stage and F1 adult progeny of *Rhyzopertha dominica* species. While chickpea commodity treated with 0.1% concentration of DE shows the dead visible F1 generation of *Rhyzopertha dominica* species. This means, the larva has emerged as adults but at the end of the 9 weeks of the exposure period, F1 progenies were completely suppressed. The percentage of mortality *Rhyzopertha dominica* species, weight reduction of chickpea commodity, and the emergence of the progeny of *Rhyzopertha dominica* species depend upon the different concentrations of DE and applying 1% of DE highly effective concentration to control the *Rhyzopertha dominica* species in the chickpea commodity.

Keywords **-** Diatomaceous earth, Percentage of mortality, *Rhyzopertha dominica*

1. INTRODUCTION

Insects are the major cause of the storage losses in grains (Nukenine *et al.*, 2010). 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 (Quarles and Winn, 1996). 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 (Ebeling, 1971). DEs are of extremely low toxicity to mammals (Korunic *et al.*, 1994). The lesser grain borer is a serious pest of stored grain worldwide (Stathers *et al*., 2002). Several reports showed that the lesser grain borer can be controlled using DE (Fields and Korunic, 2000). 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. 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 chickpea 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.

2. MATERIALS AND METHODOLOGY

2.1 Location

Experiment was conducted in Department of Agricultural Engineering, Faculty of Agriculture, University of Jaffna from March to May 2021.

2.2 Grain selection

For the experiment 5 kg of chickpea, those are commercially harvested were obtained from local market of Jaffna, Sri Lanka.

2.3 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 raised platform, so as to prevent spoiling of grain through moisture movement from the floor.

2.4 Grain treatment

The five treatments (T_1 (0.01%), T_2 (0.05%), T_3 (0.1%), T_4 (0.5%), T_5 (1%) and control (untreated samples)) were set based on different concentration of DE on mass weight basis with one untreated sample as a control.

2.5 Experimental design

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

2.6 Species introduction

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

2.7 Sample analysis

Insect counting: From 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. Counting was done manually to determine sample populations of dead and live insects with the help of forceps and a tally counter. After 5th weekend onwards, the samples were let to progeny development without any disturbance. The number of live and dead adult progenies (F_1) were counted 9th weekend.

Grain damage assessment: The weight reduction of grain was measured by using weighing balance after removal of all dead and live insects and all inert matter in 7 days interval.

Data analysis: MS Excel was used for data entry and summarizing the required variables. Data was 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.

3. RESULT 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, 1% concentration shows a high % of mortality and 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.

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 the 9 weeks of exposure period F1 progenies completely suppressed. Also, progeny production notably

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

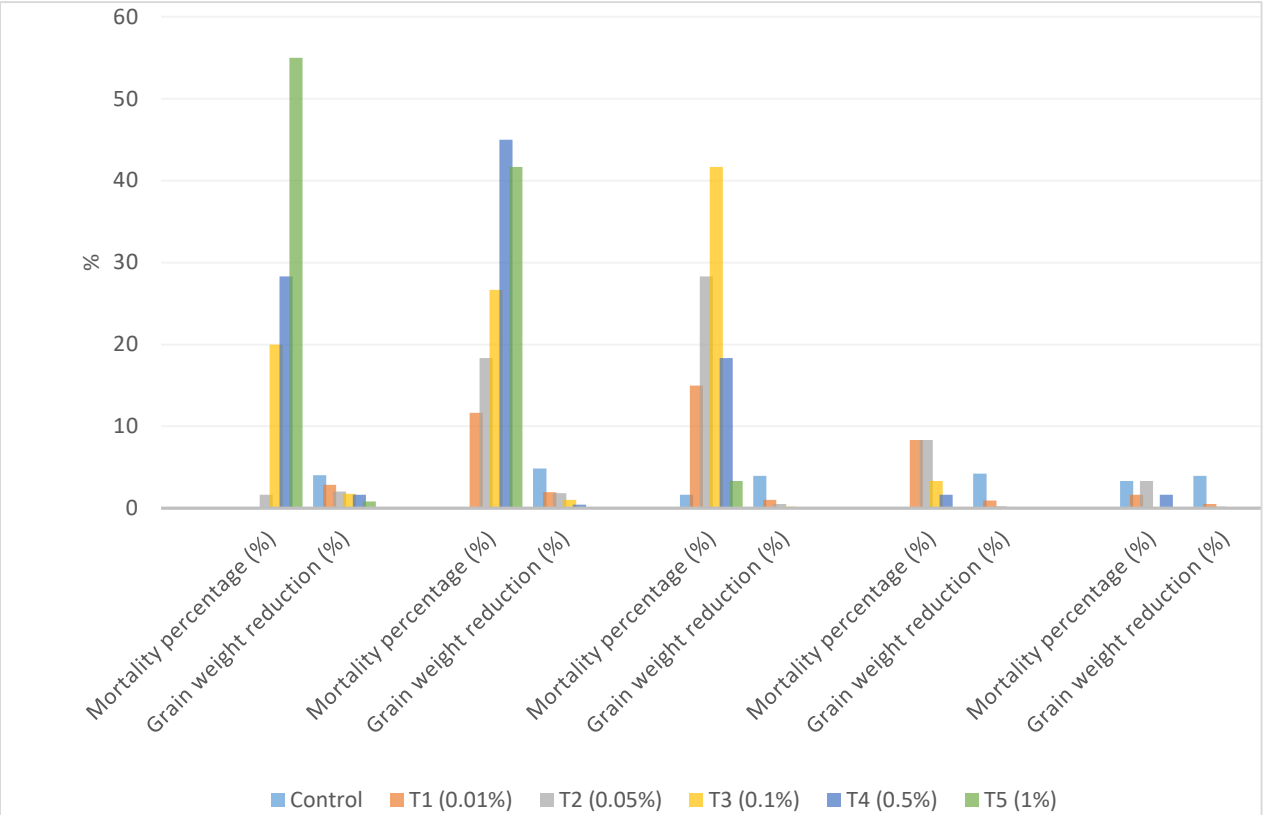

Figure 1: Mortality percentage of *Rhyzopertha dominica* and weight reduction of chickpea commodity with time.

reduced in the 0.05% of DE concentrated chickpea commodity. Likewise, progeny production in the 0.01% of DE concentrated chickpea commodity was decrease almost two times comparing with control.

4. 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 concentration 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 commodity 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 commodity.

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