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Diatomaceous Earth vs. Kaolinite Clay for Rice Weevil Control in Wheat

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ABSTRACT: An experiment conducted at the seed center laboratory at Tamil Nadu Agricultural University during June 2022, compared the efficacy of diatomaceous earth and kaolinite clay against rice weevil (*Sitophilus oryzae*) infestations in stored wheat. Adult weevils exposed to treated wheat grains exhibited dose-dependent mortality. Diatomaceous earth demonstrated rapid insecticidal activity, achieving 100% mortality at the highest dosage (1g/100 g wheat) within seven days while causing minimal grain damage. In contrast, kaolinite clay exhibited slower action, achieving 90% mortality at 30 days, with moderate grain protection. Additionally, diatomaceous earth significantly reduced progeny emergence. These findings highlight diatomaceous earth as a more effective and faster-acting solution for controlling rice weevils in stored wheat compared to kaolinite clay, emphasizing its potential for integrated pest management strategies in grain storage facilities.

Keywords: Diatomaceous earth, Kaolinite clay, Rice weevil, Inert dusts.

INTRODUCTION

Grains are an essential food source globally, rich in important nutrients that support overall health. Whole grains, in particular, help to manage cholesterol, control weight, and regulate blood pressure. Studies indicate regular consumption of whole grains can significantly reduce the risk of chronic diseases like diabetes and heart disease (Mattia *et al.,* 2022). However, a major challenge is the loss of grains after harvest, especially during storage, which threatens global food security. Reducing these losses is vital to ensure the availability of this essential nutrient source for future generations (Hodges *et al.,* 2011; Stathers *et al.,* 2013).

A major cause of grain losses after harvest is insect pests such as the rice weevil. Traditional pest control methods usually involve chemical insecticides and fumigants. While these chemicals can be effective, they come with serious problems such as pests developing resistance (Benhalima *et al.,* 2004; Collins *et al.,* 2005), environmental pollution (Rajashekhar *et al.,* 2012), and potential health risks to humans (Aulicky *et al.,* 2019). As a result, there is an increasing demand for sustainable pest management alternatives. One such alternative is using inert dust and ash, which control grain pests by physically disrupting them. The effectiveness of these materials depends on factors like the type of material, the pest species' susceptibility, the concentration used, the duration of exposure, and the adherence of the dust to the pests (Christos *et al.,* 2016; Kanteh *et al.,* 2016; Ofuya and Akhidue 2005; Shah *et al.,* 2006; Shams *et al.,* 2011).

The rice weevil, *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae), is a significant and destructive pest of wheat and various other crops (Hatami *et al.,* 2011). This pest is responsible for considerable reductions in both the quantity and quality of stored grains globally (Arannilewa *et al.,* 2002). The adult weevils bore circular holes into the grains, consuming mainly the endosperm and thereby diminishing carbohydrate content. The larvae preferentially feed on the grain germ, leading to substantial losses in protein and vitamins. Traditionally, synthetic pesticides and phosphine gas have been widely used to manage stored grain insect pests, including rice weevils, across the world (Anwar *et al.,* 2003). However, due to the rise in phosphine resistance, particularly in countries like Australia and India, control measures are becoming increasingly ineffective (Mau *et al.,* 2012; Ali *et al.,* 2013). While chemical insecticides such as deltamethrin (Decis 2.5 WP; 40 mg/kg) (Mishra and Panday 2014), malathion, and fenvalerate (Singh *et al.,* 1998) have shown effectiveness against rice weevils, their usage comes with significant drawbacks, including residual toxicity, pollution, and negative impacts on both food safety and human health, along with rising costs (Lu and Wu 2010). Therefore, considering the environmentally friendly nature, consumer safety, and reduced likelihood of inducing pest resistance associated with inert dusts, the present study investigated the effectiveness of diatomaceous earth and kaolinite clay as potential solutions for managing rice weevil populations.

MATERIALS AND METHODS

Adult rice weevils (*Sitophilus oryzae*) used in this study were obtained from the seed center laboratory at TNAU AC and RI, Coimbatore. These weevils were cultured on a standard wheat variety. Standardized containers, each filled with 100 grams of wheat, were treated with selected inert dusts of diatomaceous earth and kaolinite clay at increasing dosages of 0.25, 0.5, and 1.0 grams per 100 grams of wheat. A control group with untreated wheat was also included. Each treatment, along with the control group, was replicated three times.

Table 1: Treatment details for the experiment diatomaceous earth vs kaolinite clay against rice weevil.

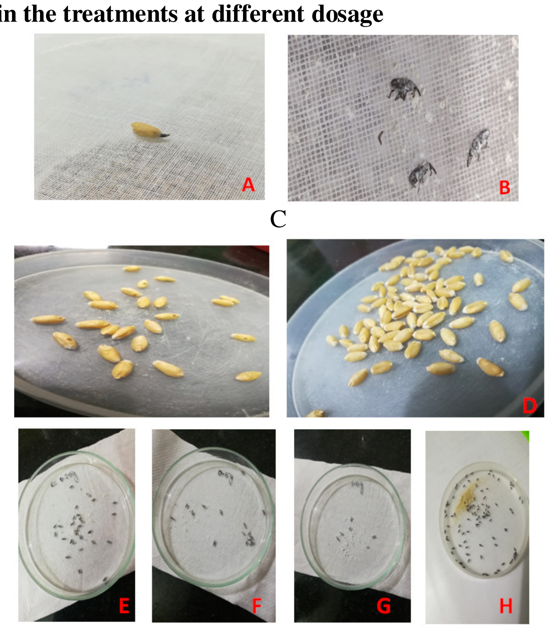
Inert Dusts	Dosages (g/100g of wheat grains)
Diatomaceous earth (DE)	0.25g, 0.5g, and 1gfor each replication respectively
Kaolinite clay	

Twenty adult weevils were introduced into each container. To monitor mortality, observations were made at regular intervals: 5, 10, and 15 days after the weevils were introduced. During each observation, dead insects were counted and removed, allowing the remaining live weevils to continue reproducing. The containers were revisited at later stages (25, 35, 40, and 50 days) to assess the impact on the next generation (F1 progeny) by counting the emerged adult offspring. Upon observing any F1 progeny, treatments in those containers were continued until complete mortality was achieved. Ultimately, the mortality rate and grain damage were determined at the end of the experiment using the following formula,

$$\text{Percent mortality} = \frac{\text{No. of dead insects}}{\text{Total no. of insects}} \times 100$$

$$\text{Percentage of seed damage} = \frac{\text{No. of damaged grains}}{\text{Total no. of grains used}} \times 100$$

Observations made on the mortality of rice weevils in the treatments at different dosage



A	Internal feeding
B	Dead adults (Through desiccation caused by inert dusts)
C	Number of damaged grains
D	Number of undamaged grains
E F G H	Analysis ofthe number of adults (Dead vs Alive) in each replication and control (H)

RESULTS AND DISCUSSION

Diatomaceous earth

Short-Term Effects (3 Days After Treatment). Three days after treatment (3 DAT), diatomaceous earth demonstrated significant effectiveness in eliminating adult insects. The study identified a dose-dependent relationship, with higher dosages resulting in higher mortality rates (Fig. 1). At the lowest dosage (0.25g), the average mortality rate was 27.6%, while the highest dosage (1g) achieved a more substantial mortality rate of 77% (Table 2).

Long-Term Effects (7 Days After Treatment). Seven days after treatment (7 DAT), diatomaceous earth exhibited remarkable effectiveness. The highest dosage (1g) resulted in the complete elimination of all adult insects, highlighting its potency. Even at lower dosages, significant mortality rates were observed: 66% at 0.25g and 83% at 0.5g (Table 3). Importantly, grain damage was minimal across all dosages, with the highest being 8% at the 0.25g dose and the lowest being 3% at the 1g dose. This indicates that diatomaceous earth not only effectively eliminates adult insect populations but also protects grains from pest damage over a longer period.

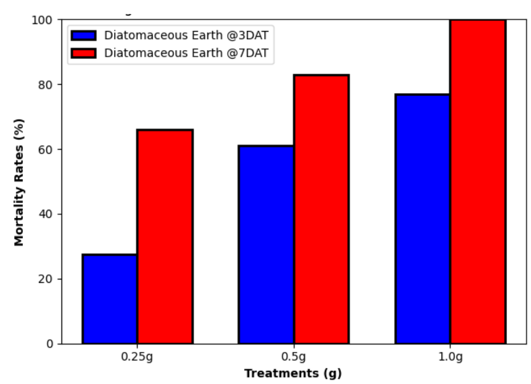


Fig. 1. Effects of diatomaceous Earth on Rice Weevil

Kaolinite clay

Short-Term Effects (15 Days After Treatment). The findings indicated that kaolinite clay effectively controls adult insect populations over an extended period. Within the initial 15 days of treatment, a dose-dependent trend in mortality rates was observed. The highest dosage (1g) resulted in an average mortality rate of 44%, while the 0.5g dosage yielded 22% mortality, and the 0.25g dosage showed no mortality (Table 4).

Table 2: Effect of Diatomaceous Earth on Rice weevil @ 3 DAT.

DIATOMAECOUS EARTH – ADULT POPULATION @ 3 DAYS AFTER TREATMENT								
Dosage (g)	R1		R2		R3		AVERAGE DEAD INSECT	Mortality %
	ALIVE	DEAD	ALIVE	DEAD	ALIVE	DEAD		
0.25	4	2	5	1	4	2	1.66	27.6
0.5	2	4	3	3	2	4	3.66	61
1	1	5	2	4	1	5	4.66	77

Table 3: Effect of Diatomaceous Earth on Rice weevil @ 7 DAT.

DIATOMAECOUS EARTH – ADULT POPULATION @ 7 DAYS AFTER TREATMENT									
Dosage (g)	R1		R2		R3		AVERAGE	Mortality %	Grain damage % (out of 100grains)
	Alive	Dead	Alive	Dead	Alive	Dead			
0.25	2	4	2	4	1	5	4.33	66	3
0.5	0	6	2	4	1	5	5	83	5
1	0	6	0	6	0	6	6	100	8

Table 4: Effect of Kaolinite clay on Rice weevil @ 15 DAT.

KAOLINITE CLAY – ADULT POPULATION @ 15DAYS AFTER TREATMENT								
Dosage (g)	R1		R2		R3		AVERAGE DEAD INSECTS	Mortality %
	ALIVE	DEAD	ALIVE	DEAD	ALIVE	DEAD		
0.25	6	-	6	-	6	-	0	0
0.5	4	2	5	1	5	1	1.33	22
1	4	2	3	3	3	3	2.66	44

Table 5: Effect of Kaolinite Clay on Rice weevil @ 30 DAT.

KAOLINITE CLAY – ADULT POPULATION @ 30 DAYS AFTER TREATMENT									
Dosage (g)	R1		R2		R3		AVERAGE	Mortality %	% Grain damage (out of 100 grains)
	Alive	Dead	Alive	Dead	Alive	Dead			
0.25	-	19	19	54	1	27	33.33	83	9
0.5	8	9	-	11	-	8	9.33	77	5
1	2	8	-	6	-	6	6.66	90	2

Long-Term Effects (30 Days After Treatment). After 30 days, the impact of kaolinite clay became more pronounced and displayed a significant dose-dependent relationship (Fig. 2). The highest dosage (1g) achieved an impressive 90% reduction in insect populations. Even the lower doses were effective, with the 0.5g dosage resulted in 77% mortality and the 0.25g dosage achieved 83% mortality (Table 5).

Additionally, kaolinite clay proved to be a valuable protector of grains, minimizing damage across all dosages. Grain damage was lowest at 2% with the highest dosage and up to 9% with the lowest dosage, demonstrating that kaolinite clay is a promising and sustainable alternative to traditional pesticides.

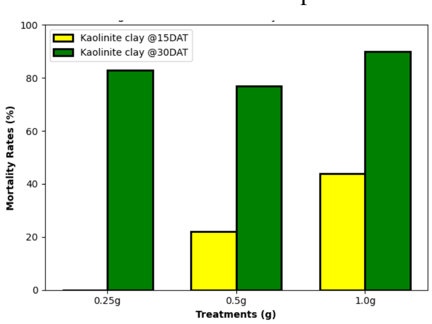


Fig. 2. Effects of kaolinite Clay on Rice weevil.

Our results were on par with the previous studies where, the inert dusts, particularly kaolinite clay and diatomaceous earth, reported to effectively prevent the adult weevil emergence, achieving a (0% emergence rate) and protecting seeds from damage and weight loss at all tested concentrations (1g, 5g, and 10g per 100g of seeds) (Akbar *et al.,* 2021). Another study revealed that, among the treatments, diatomaceous earth was the most effective against all three insect species tested, followed by kaolinite clay and katelsous. However, the effectiveness of those treatments decreased over time (El-Sayed *et al.,* 2010).

Arthur and Throne (2003) found that rice weevils are particularly susceptible to diatomaceous earth compared to other insects. They also noted that factors such as grain temperature and moisture content can impact the effectiveness of this treatment. Our study's findings are also consistent with these observations.

Overall, this study reinforces the potential of diatomaceous earth and kaolinite clay as sustainable alternatives to chemical insecticides for protecting stored grains. Although the efficacy of these treatments may decrease over extended storage periods, their initial effectiveness in controlling pest populations and ensuring consumer safety makes them valuable components of integrated pest management strategies.

CONCLUSIONS

The experiment was conducted to study the effect of inert dusts against Rice weevil (*Sitophilus oryzae*) onwheat host using two treatments (Diatomaceous Earth and Kaolinite Clay) at different dosages under three replications. Our observations revealed that, the Diatomaceous Earth @ 1.0 g dosage on 7 DAT was more effective since 100% mortality was attained whereas Kaolinite clay was less effective as even @ 1.0 g, it resulted in 90% mortality, only on 30 DAT and also had increased progeny population compared with Diatomaceous Earth treatments. Thus, it is concluded that the among tested inert dusts, Diatomaceous Earth was found to be more effective than Kaolinite clay within a short period of treatment, with significant effect on progeny population and minimum grain damage.

FUTURE SCOPE

Future research should focus on optimizing the use of these inert dusts as an IPM component and exploring additional factors that could affect their performance against different storage pests under various storage conditions.

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Conflict of Interest. None.

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