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Evaluation of toxic efficacy of silicon oxide nanoparticles on *Sitophilus oryzae* (L.) on Stored Maize grains under Laboratory conditions

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ABSTRACT

This laboratory study aimed to evaluate the efficacy of Silicon Oxide Nanoparticles against *Sitophilus oryzae* (L.) on stored maize grains. In the experiment, six different concentrations of SiO_2 NPs i.e., 100, 150, 200, 250, 300, and 500 ppm were tested on *S. oryzae* along with control. The results showed that nanosilica @ 500 ppm was most effective, resulting 100% mortality on five days after treatment followed by nanosilica @ 300 and 250 ppm which resulted in 100% mortality at eleven days after treatment. Also, no adult emergence was observed in maize treated with SiO_2 NPs even after sixty days of the treatment. This study revealed the promising role of SiO_2 NPs in wholesome development of sustainable agrobusiness.

Key Words - *Zea mays*, *Sitophilus oryzae*, Silicon Oxide Nanoparticles, Adult mortality (%).

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INTRODUCTION

Maize [*Zea mays* (L.)] is popularly known as 'Queen of Cereals' due to its high nutritional value, multiple utilities and high genetic yield potential. It is one of the most versatile crops grown in various agroclimatic zones i.e., from 58°N to 40°S, from below sea level to altitudes higher than 3000m, and in areas with 250 mm to more than 5000 mm of rainfall per year (Shaw R. H., 1988). Maize being a multipurpose crop, is widely used as food, cattle and poultry feed, fodder, and recently has been adopted as a source of biofuel production. In terms of nutritional benefits, it proves to be a key source of various phytochemicals which helps in lowering the risk of major chronic diseases. Being the 3rd most widely produced crop, maize is considered as a pivotal commodity in many countries and effective post- harvest management can provide a significant push to its production. With this, it becomes important to ensure proper handling and protection of stored maize grain from any kind of damage or loss.

Storage losses are the result of both Abiotic stresses (such as humidity, temperature) as well as Biotic stresses (like insects, pests, fungi, rodents). The insect pests attacking maize farmland are different from species those attacking the stored maize grains and *Sitophilus oryzae* (L.) is one of the most destructive pests directly affecting the quality and marketability of maize worldwide. *S. oryzae* is small insect pest having reddish-brown to blackish colored integument and nearly cosmopolitan distribution. Irrespective of different measures being taken, *Sitophilus* species continue to be the major pest of stored grains till date and thus a new promising technology i.e., 'Nanotechnology' has come into play.

Nanoparticles (NPs) are wide class of materials that include particulate substances, which have at least one dimension less than 100 nm (Laurent *et al.*, 2010). They are being used in the form of nanofertilizers, nanoemulsions, nanosensors and nanopesticides for improving both the quantity and quality of crop and stored grains. Unlike conventional pesticide formulations, the nanoformulations are specially designed to increase the solubility of insoluble or poorly soluble active ingredients and to release the biocide in a controlled and targeted manner (Margulis & Magdassi, 2013). There are various types of Metal and Metal Oxide nanoformulations which have been found useful in agricultural practices like Silver Nanoparticles (Ag NPs), Aluminium Oxide Nanoparticles (Al_2O_3 NPs), Silicon Oxide Nanoparticles (SiO_2 NPs), Zinc Oxide Nanoparticles (ZnO NPs), and Titanium dioxide (TiO_2 NPs). Among all these, SiO_2 NPs are found to have greater efficiency as stored product protectant due to its high thermal stability, excellent biocompatibility and mesoporous property. Though earlier pest management in agriculture has relied on use of conventional insecticides which often posed negative impacts on non-targeted organisms and environment, thus new and updated alternatives are needed and nanoparticles are proving to be a good option in this regard.

MATERIALS AND METHODS

- **Experiment place**

The entire experiment was performed in the Entomology Laboratory of University Department of Zoology, Ranchi University, Morabadi campus, Ranchi, Jharkhand, India, during late March and early April months in the year 2022.

- **Nanoparticles Used**

SiO_2 (Colloidal Silicon oxide) Nanoparticles was obtained from Nano Research Lab, Gopalpur, Asansol, East Singhbhum, Jamshedpur, Jharkhand, India.

Supplier : Nano Research Lab

Product Code : NRL-CSN033

Form : Translucent liquid

Color : Colourless

Solubility : Dispersed in Water

Packsize : 250mL

Purity : 99.9%

APS : 10-20nm

- **Test Insect**

Sitophilus oryzae (L.), commonly called Rice weevil is the experimental insect. The rice weevils were collected from a wholesale grain store of Krishi Bazar, Pandra Road, Ranchi. The weevils were allowed to rear in healthy, uninfested maize grain under laboratory condition at temperature 30±2°C and 35±5% R.H. in continuous darkness. After few generations completed, new adults were chosen for performing the present experiment.

- **Collection of Grain Sample**

300g of maize grains were purchased from a wholesale grain store of Piska More, Ranchi, Jharkhand.

- **Bioassay**

The maize grains collected from the grain store was properly washed and then left to dry in sunlight. After proper drying, seven batches of maize grains with 20g in each were prepared using weighing machine and three replicates were maintained. Small-sized container with radius 7 cm and height 5 cm were used for this purpose. The grains were sterilized at 60°C in Hot air oven for about 30 minutes and was then left for acclimatization to regain moisture. Simultaneously, six different concentrations of SiO_2 NP_S i.e., 100, 150, 200, 250, 300 and 500 ppm were prepared using 1000ppm stock solution of colloidal SiO_2 NP_S. Maize in each container was treated individually with SiO_2 NPs of different concentrations as mentioned above (except one set which served as control). Same process was performed in three replicates for each dose. After the treatment of maize grains, the containers were carefully shaken for approximately one minute so that there is uniform distribution of SiO_2 NPs over maize grains and were left for drying to avoid any fungal growth and after 24 hours, 20 adults of *S. oryzae* were introduced in each treated maize container and also in the control. Now, the

Insect mortality was assessed at 1,3,5,7,9,11,13 and 15 days after treatment.

Adult mortality (%) of *S. oryzae* was calculated by using the formula (Devi *et al*., 2014):

$$\text{Adult mortality (\%)} = \frac{\text{Number of dead insects}}{\text{Total number of insects}} \times 100$$

RESULTS

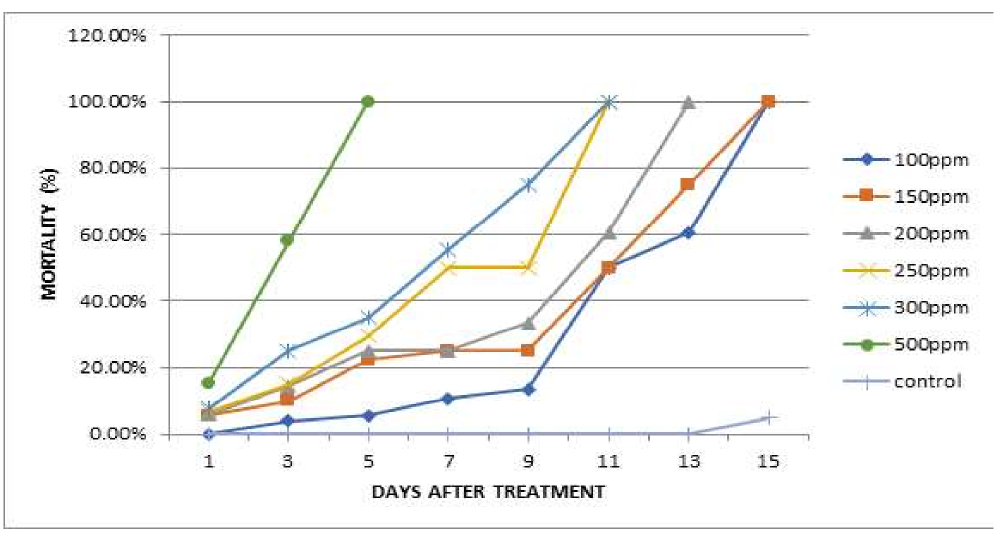
The present study clearly depicts the efficiency of SiO_2 NPs against adult *S. oryzae*.

Table 1 represents the adult mortality (%) at different concentrations of SiO_2 NPs i.e., 100ppm, 150ppm, 200ppm, 250ppm, 300ppm and 500ppm.

Table 1: Adult mortality (%) at different concentrations of SiO_2 NPs.

SiO_2 NPs Treatment (in ppm)	Adult Mortality (%) Days after Treatment (DAT)							
	1	3	5	7	9	11	13	15
100	0.00	3.85	5.56	10.76	13.36	50.00	60.67	100.00
150	5.56	10.00	22.22	25.00	25.00	50.00	75.00	100.00
200	5.88	14.28	25.00	25.00	33.33	60.66	100.00	
250	6.67	15.00	29.41	50.00	50.00	100.00		
300	7.69	25.00	35.00	55.56	75.00	100.00		
500	15.00	58.00	100.00					
CONTROL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00

SiO_2 NPs was found to be very effective against *S. oryzae* as adults' mortality (%) was obtained on 1st DAT with 500ppm: 15.00%, 300 ppm: 7.69%, 250ppm: 6.67%, 200 ppm: 5.88% and 150 ppm:5.56% mortality. In lower concentration i.e., 200ppm, adult mortality percent ranged between 5.88% to 100% from 1 to 13 days post treatment while at higher concentration i.e., 300ppm, the adult mortality percent ranged between 7.69% to 100% from 1 to 11 days after treatment. The results showed that nanosilica @ 500 ppm was most effective, resulting 100% mortality on five days after treatment followed by nanosilica @ 300 and 250 ppm which resulted in 100% mortality at eleven days after treatment. Also, no adult emergence was observed in maize treated with SiO_2 NPs even after sixty days of the treatment.



Graph 1: Bioassay of SiO_2 NPs on adult *S. oryzae.*

DISCUSSION

The result showed highest efficacy of SiO_2 NPs at 500ppm. This is in accordance with the experimental results of Padmasri *et al.* (2018). They studied the effect of nanoparticles, viz, nano silica, nano alumina and nanoclay at three different dosages, i.e., 500, 250,125 ppm kg^{-1} maize seed and found nanosilica applied at 500ppm/kg dosage to be superior over other treatments. In the present study it was found that adult mortality (%) increased when concentration of treatment was increased along with the time of exposure. This in accordance with findings of Gamal M.M. (2018) who reported that Mortality (%) increased and weight loss (%) decreased with increase in concentration and exposure period in his work conducted on *S. oryzae.* The SiO_2 NPs can be used as stored product protectant against stored pest. This is in accordance with the findings of Rouhani *et al.* (2012) and Arumugam *et al.* (2015) who worked on *Callosobruchus maculatus* and recommended SiO_2 NPs as a valuable tool in pest management programs.

CONCLUSION

The present study revealed SiO_2 NPs a protective agent against *S. oryzae* on stored maize grains. Thus, indicating the use of NPs as an alternative of conventional insecticides and presenting the idea of sustainable agriculture.

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