International Journal of Engineering, Science and Mathematics
Vol. 12 Issue 4, April 2023
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in , Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Effect of Zinc Oxide Nanoparticles prepared by green route on *Spodop tera frugiperda* under laboratory conditions

Dr. Sunita Kumari, Assistant Professor, Department of Zoology, Ram Krishna Dwarika College, Patliputra University, Patna-20

Abstract

Spodoptera frugiperda also known as Fall armyworm (FAW) is a Lepidoptera in the family Noctuidae. It is a major pest of corn, rice, maize and other crops which are generally controlled by insecticides that can cause harm to environment. Currently, the robust development of nanotechnology is taking prime role in the agricultural industry as proper alternative of traditional pes management with efficient and safe characteristics. The present study sought to determine the efficacy of Zinc Oxide (ZnO) nanoparticles (NPs) towards *S. frugiperda* under certain condition. Different concentrations of ZnO nanoparticles were used to control the Fall armyworm. The ZnO nanoparticles were prepared by environment friendly green route. The different concentration shows that the mortality rate increases with increase in concentrations. The ZnO nanoparticles-based solution can be used as insecticides.

Keywords:

Fall armyworm; *Spodoptera frugiperda*; Zinc Oxide nanoparticles; insecticides.

Author correspondence:

Dr. Sunita Kumari, Assistant Professor, Department of Zoology, Ram Krishna Dwarika College, Patliputra University, Patna-20
Email: smondalakpc@rediffmail.com

1. Introduction

In any country the robust system of food supply depends on its storage system. Stored grains can be damaged by a number of reasons among which insect pests are responsible in most cases. The pests infest grains to fulfil their livelihood but this can result in both quantitative and qualitative losses. The tropical climate of India is extremely favourable for constant occurrence of storage insect pests throughout the year. The pests can develop at any stage of storing and results in a large amount of damage [1]. Maize is the most important cereal crop being cultivated all over the globe and it is widely use as feed, fodder and raw materials for industrial applications. In India, the third most important cereal considering both amount of cultivation and production is maize after rice and wheat [2]. Though maize is considered as one of the emerging crops used in industries, its production is not up to the mark. In this condition, wastage due to pest attack is very much problem for farmers as well as dependant industries.

Spodoptera frugiperda also known as Fall armyworm (FAW) is a Lepidoptera in the family Noctuidae that was first mentioned by James Smith and Abott Fall [3]. Fall armyworm is a polyphagous insect pest of more than one hundred plant species with a preference for gramineous species mainly causing damage to economically important cultivated cereals such as rice, wheat, maize, crabgrass, and also to different green vegetable and cotton. It is termed as one of the most harmful pests which causes devastative damage to the maize all over America, Africa, Asia including India [3-5]. It affects the maize plants severely. The mature larvae, visible or hidden in the twist, amongst large quantities of fresh faecal pellets can be observed with patches of dry frass on outer leaves [6]. The male moths in their adult stage have greyish-brown mottled forewing with light and dark splotches, The female moth has a noticeable spot near the forewing, the hind wing is iridescent silver-white with a narrow dark border. [7]. The larvae of Fall armyworm have four pair of pro-legs. It may be easily resembled with corn earworm but a special type of 'Y' shaped white inverted mark near to its front head differentiates them. Fall armyworm has brown head with dark honeycombed markings [8]. This moth can fly up to 100 kms area at night easily and females laid eggs (about 1500 on an average) after migration. The eggs last for 3-4 days in warm weather. The life cycle of the moth is about 30-45 days and in cool weather it may extend up to 60-90 days. FAW has six larval instar stages before pupation and this stage lasts for 14-30 days depending on weather conditions. The spreading of FAW increases in Indian climate [9-10].

Currently, nanotechnology has become very much attractive to all the researchers due to its wide range of application in various fields including medicine, agriculture, and electronics [8]. Nanoparticles refers to the dimension of the particles in the range of few nanometres to 100 nanometres. Nanomaterials have gained popularity among users as well as researchers for their unique properties which largely differ from that of bulk. The large surface to volume ratio of nanomaterials have made them useful for medical and agricultural uses. The large number of chemical insecticides and their excess uses have devastated our human health along with environment. Uses of nanomaterials in those cases can decrease the adverse effect of those things. A lot of nanomaterials have proved to be very much efficacious against weeds, plant pathogens, and insect pests. Till now the detailed mechanisms of nanoparticles have not been understood in respect of their applications as insecticides. So, we need to study their interaction with biological system. Therefore, formulation of nanomaterials to prepare insecticides and insect repellents is very much essential [11-12].

Metal oxide nanoparticles such as CuO, CaO, SiO_2, ZnO etc can be used as insecticides and repellent due to their efficient characteristics [13]. Among all these zinc oxide nanoparticles (ZnO-NP) has become attractive to the users due to its chemical and physical versatile properties [14-15] Remarkably, zinc oxide has proved to hold great potential in the biosynthesis of nanoparticles for medical purposes. Recently zinc oxide nanoparticle has been prepared from different plant extract such as spinach leaves, *Hibiscus rosasinensi, Cassia auriculata*, Passifora caerulea, Scadoxus multiforus, Camellia sinensis, *etc.* [15]. The prepared ZnO nanoparticles through green route shows remarkable antimicrobial efficacy in many cases. In this work, the research was conducted to determine the efficacy of ZnO nanoparticles prepared by green route towards *Spodoptera frugiperda.* Moreover, the study relates the different condition achieved to control the effect of *Spodoptera frugiperda* on crops under Indian climate condition.

2.Materials and Methods

2.1 Area of this study

The experiments related to the study were conducted at different agricultural sight of Kishanganj area. Land of individual persons were used in this purpose and selected side was isolated from other area. The five such area was marked L1 to L5. Due to the invasive nature of the fall armyworm (FAW), all observations were recorded under quarantine facilities.

2.2Fall armyworm nurture

The samples of FAW were collected from L1 to L5 area and kept at special plastic container of dimension 200 cm x 250cm x 150 cm. The samples consist of larvae, pupae and adults of fall armyworm. The room arrangement for FAW was done with home-made arrangements and the photoperiod of 12 hours for Day and Night each was maintained. The humidity measured was about 75 ± 5 % with room temperature about 30 ± 2 °C.

2.3 Synthesis of *Zinc Oxide Nanoparticles*

The chemical used here are of analytical grade and purchased from SRL pvt ltd, India. The zinc oxide nanoparticles are prepared through Sol-gel method using green synthesis process. First of all, 0.3 g of the Arabic gum (AG) was dissolved in 50 mL of deionized water and stirred for 2 hours at 80 °C to attain a clear Arabic gel (AG) solution. Then, 2 g of Zinc Nitrate [Zn (NO3)2.6H2O] was mixed to the AG solution. Then, the beaker containing the solution was put on a sand bath maintained at a fixed temperature of 80°C.The solution was stirred properly for continuous 15 h to obtain a brown-coloured resin. The final material was calcined at 600 °C temperatures in air for 3 h to obtain a white powder of ZnO. The powder was crushed in a mortar properly and collected.

2.4 Preparation of Different Concentrations of the Insecticide

The zinc oxide powder was characterized and then different concentrations of solution was prepared by dissolving this nano-powder in distilled water, viz., 0, 20, 40, 60 mg/L. The solutions are referred as Z1, Z2, Z3 and Z4. Distilled water used was double distilled.

2.5 Application of prepared Insecticide on Crop

The prepared solution was spread over the area L1 to L5 for 10 minutes. Each land area was subdivided in four part to apply four different concentrations of solution termed as Z1, Z2, Z3 and Z4. After spraying, it was left to dried down in room temperature. The FAW sample nurtured previously were allowed to feed upon the treated leaves of maize in which different concentration of ZnO nanoparticle-based insecticide was spread. There were four different part of crop area along with the untreated control. The source of food was supplied to the samples and replaced each third day. Folded paper pieces will be hung in the container containing FAW samples for egg-laying. This egg numbers which convert in larvae was subtracted from the number of deaths of the larvae samples.

2.6 *Statistical analysis*

Standard procedures were maintained to record the statistical data regarding number of deaths of larvae, pupae and adult FAW. The collected data was analysed using ANOVA method. The rate of mortality was calculated for different ZnO NP concentration. The analysed means were compared by the Least Significant Difference test (LSD) for their significance at the 0.05% probability level.

3.Result and Discussion:

3.1 Characterization of ZnO nanoparticles:

The structural and morphological properties of as prepared ZnO nanoparticles are characterized using X-Ray diffraction (XRD). scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The XRD pattern (Figure 1) shows formation of mixed phase of ZnO. The recorded peak at (111) plane is for cubic ZnO. Zinc blende phase with space group F43m (ICDD 065-2880). Other peaks match the hexagonal phase with space group of P63mc (ICDD 075-1533). The TEM images as shown in figure 2 confirm presence of nanoparticles with size averagely about 80-100 nm. The SEM image (Figure 3) shows formation of spherical shapes ZnO nano powder with average size 200-220 nm. This may be due to agglomerations. The optical characterization was done by UV-Vis's photo spectrometer which is shown in figure 4. The absorbance spectra for wavelength 200-700 nm were shown and a peak at 372 nm confirms presence of ZnO nanoparticles.

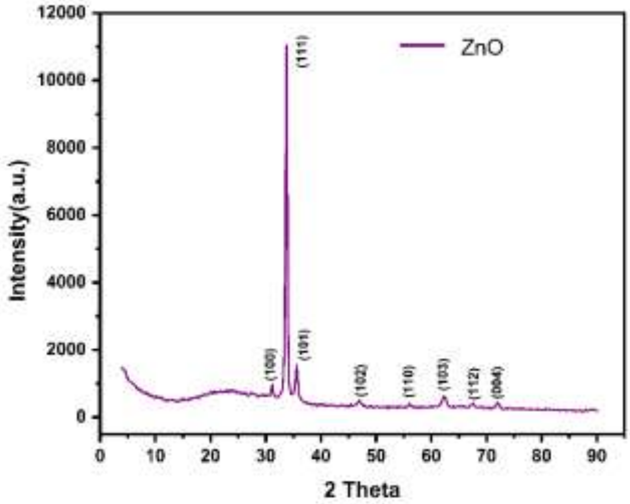

Figure 1: XRD of ZnO Nanoparticles

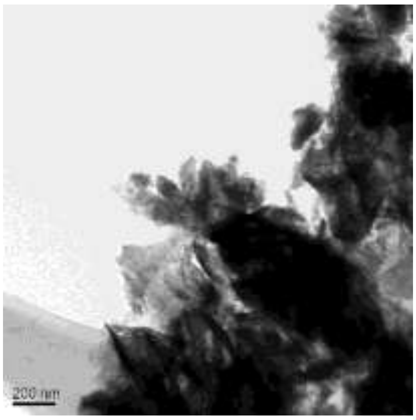

Figure 2: TEM images of ZnO Nanoparticles

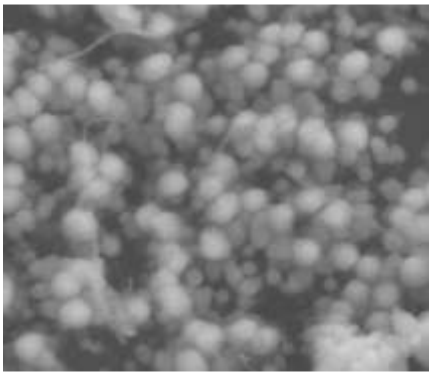

Figure 3: SEM images of ZnO nanoparticles

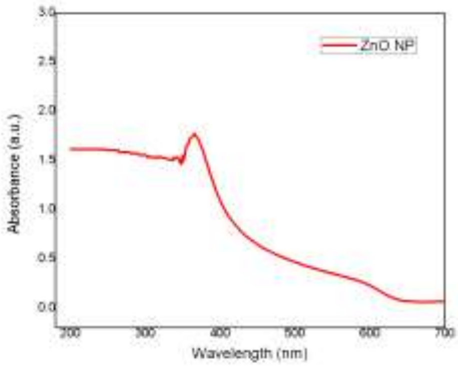

Figure 4: Absorbance vs Wavelength for ZnO nanoparticles

3.2 Effect of ZnO nano particles on mortality of *Spodoptera frugiperda:*

Table 1 shows the result for different concentrations of ZnO nanoparticles over *Spodoptera frugiperda (FAW).* The made insecticides of different concentration was sprayed in first day, third day and fifth day on each land area labelled as L1-L5. The average result for each concentration covering all the land samples was denoted in the table. The cumulative mortality rate was recorded and mean was calculated for Day 1, Day 3 and Day 5. The mortality increased with the increasing concentration for every sample collected from different crop land. Same pattern was observed for sample containing zero ZnO nanoparticle concentration.

Table 1: Cumulative mortality rate for different concentration of ZnO Nanoparticles.

Composition	Concentration	Cumulative Mortality			Mean Mortality
		Day 1	Day 3	Day 5	
ZnO nanoparticles	Z1	00	06.86	12.88	06.58
	Z2	12.14	18.80	24.50	18.48
	Z3	15.84	24.60	30.20	23.55
	Z4	20.12	26.78	32.85	26.58

*L.S.D ($P \leq 0.05$)

4.Conclusions:

The results suggest that ZnO nanoparticle can be a useful alternative to the harmful insecticides. ZnO nanoparticle-based solution is a promising material for controlling *Spodoptera frugiperda (FAW)*. But its effect on environment should be studied in details further. But ZnO is expected to be less harmful and when prepared through green route , the chances to affect environment is much low. Additionally, zinc falls within the essential micronutrients in the diet of human beings and many animals and, therefore, when ingested by humans and animals, they tend to benefit rather than harm them. The result suggests that ZnO nanoparticle solutions can be used as insecticides for *Spodoptera frugiperda (FAW)* to protect maize like crops.

5. Acknowledgements: The author acknowledges The University of Burdwan for providing facilities for nanomaterials preparation. Author also acknowledges Department of Zoology, Ram Krishna Dwarika College, Patliputra University, Patna and Molecular Cell Biology laboratory, Department of Zoology, Patna University.

6. Conflicts of Interest: The authors declare no conflict of interest.

7. References:

[1] Chitra, S. and Subramanian, S., 2016, Storage insect pests and their damage symptoms: an overview. *J. Gra. Sto. Res.50-57.*

[2] Rakshit, S. and Chikkappa, G. K., Perspective of maize scenario in India: way forward. *Maize J.*, 2018, **7**(2), 49–55.

[3] FAO. Fall Armyworm (FAW)," 2017

[4] Early, R.; González-Moreno, P.; Murphy, S. T.; Day, R. Forecasting the global extent of invasion of the cereal pest *Spodoptera frugiperda*, the fall armyworm. *NeoBiota*, **2018**, no. 40, 25–50.

[5] Pittarate, S.; Rajula, J.; Rahman, A.; Vivekanandhan, P.; Thungrabeab, M.; Mekchay, S.; Krutmuang, P. Insecticidal Effect of Zinc Oxide Nanoparticles against *Spodoptera frugiperda* under Laboratory Conditions. *Insects* **2021**, *12*, 1017.

[6] Srikanth JN, Geetha B, Singaravelu T, Ramasubramanian P, Mahesh L, Saravanan KP et al. First occurrence of Fall armyworm Spodoptera frugiperda in Tamil Nadu in sugarcane in India. Journal of Sugarcane Research . 2018; 8(2):195 -202 .

[7] Ashley, T.R.; Wiseman, B.R.; Davis, F.M.; Andrews, K.L. The Fall Armyworm: A Bibliography. *Florida Entomologist*, **1989**, 76, 1, 152-202.

[8] Brindhadevi K, Samuel MS, Verma TN, Vasantharaj S, Sathiyavimal S, Saravanan M, et al. Zinc oxide nanoparticles (ZnONPs) -induced antioxidants and photocatalytic degradation activity from hybrid grape pulp extract (HGPE). Biocatalysis and Agricultural Biotechnology. 2020;28:101730

[9] Shylesha AN , Jalai SK , Anika G , Varshney R , Ojha R. Studies of new invasive pest spodoptera frugiperda and its natural enemies. Journal of Biological Control, 2018. [accessed on 19 December, 2018]

[10] FAO. Integrated management of FAW in maize- A guide for farmer field schools in Africa, 2017. http://www.fao.org/3/i8665en/i8665en.pdf

[11] Bhattacharyya, T.; Bhaumik, A.; Rani, A.; Mandal, P.U.; Epidi, S. Nano-particles - A recent approach to insect pest control.*African J. Biotechnol.* **1995**, 9, 24, 3489–3493.

[12]Thabet, A.F.; Boraei, H.A.; Galal, O.A.; El-Samahy, M.F.; Mousa, K.M.; Zhang, Y.Z.; Tuda, M.; Helmy, E.A.; Wen, J.; Nozaki, T. Silica nanoparticles as pesticide against insects of different feeding types and their non-target attraction of predators. *Sci. Rep.* **2021**, 11, 1, 1–13.

[13] Wibowo, D.; Zhao, C. X.; Peters, P. C.; Middelberg, A. P. J. Sustained release of fipronil insecticide in vitro and in vivo from biocompatible silica nanocapsules. J. Agri. Food Chem, 2014, 62, 12504 –12511.

[14] Jiang, J.; Pi, J.; Cai, J. The Advancing of Zinc Oxide Nanoparticles for Biomedical Applications. In The Advancing of Zinc Oxide Nanoparticles for Biomedical Applications. *Bioinorg. Chem. Appl.* **2018**, 1- 18.

[15] Naseer, M.; Aslam, U.; Khalid, B.; Chen, B. Green route to synthesize Zinc Oxide Nanoparticles using leaf extracts of *Cassia fistula* and *Melia azadarach* and their antibacterial potential. *Sci. Rep*. **2020**, 10, 1, 1–10.