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Research Article

STUDY THE EFFECT OF METAL OXIDE (ZnO) NANOPARTICLES ON ROOT ANATOMY OF MAIZE (*Zea Mays*)

Vinoth Kumar K

Assistant Professor, Faculty Centre for Agricultural Education and Research, RKMVERI, Coimbatore-20

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ABSTRACT

An increasing need of nanotechnology in various industries may cause a huge environment dispersion of nanoparticles in coming years. A concern about nanoparticles interaction with flora and fauna is raised due to a growing load of it in the environment. Rapid development and wide applications of nanotechnology brought about a significant increment on the number of engineered nanomaterials inevitably entering our living system. Plants comprise of a very important living component of the terrestrial ecosystem. Studies on the influence of engineered nanomaterials on plant growth indicated that in the excess content, engineered nanomaterials influences plant growth parameters. Therefore, this study revealed that the ZnO nanopartciles and their interactions with plant species affect the anatomical structure of maize and also observed the shrunken morphology of root at higher concentrations of nanoparticles.

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INTRODUCTION

Nanotoxicity, an emerging concept, is receiving increasing attention with the fast development of nanotechnology. Development of nanotechnology and the manufacture of new organic and inorganic nanosized particles or Engineered Nanoparticles may result in the release of substantial amounts of these materials into the environment. The fate and transport of nanosized materials, once they are released into the environment, has not yet been fully addressed, nor have the impacts of those materials on plant system and soil communities (Dionysiou, 2004). The main characteristic of engineered nanoparticles is their size (<100 nm), which falls in the transitional zone between individual atoms or molecule and the corresponding bulk materials. This can modify the physicochemical properties of the material as well as create the opportunity for increased uptake and interaction with biological systems. This combination effect can generate adverse biological effects in living cells that would not otherwise be possible with the same material in large form (Nel *et al.,* 2006). Other properties of engineered nanoparticles, such as high specific surface area, abundant reactive sites on the surface as a consequences of a large fraction of atoms located on the exterior rather than in the interior of engineered nanoparticles, as well as their mobility, could potentially lead to unexpected health and environmental hazards (Maynard *et al.,* 2006). Therefore, organisms and especially those that interact strongly with their immediate environments are expected to be affected as a result of their exposure to engineered nanoparticles. However, to date, plants as important ecological receptors, have not received enough toxicity research. Lin and Xing (2007) analyzed phytotoxicity of five types of multiwalled nanoparticles at the level of seed germination and root growth in six higher plant species (*Raphanus sativus*, *Brassica napus*, *Lolium multiflorum*, *Lactuca sativa*, *Zea mays* and *Cucumis sativus*). Seed germination was not affected except for the inhibition of nanoscale zinc on *Lolium multiflorum* and nanoscale zinc oxide on *Zea mays*. Inhibition of root growth varied greatly among nanoparticles and plants and it is partially correlated to nanoparticles concentration. Yang and Watts (2005) investigated the phytotoxicity of nano-scale alumina powder with or without phenanthrene coating on five plant species (*Zea mays, Cucumis sativus, Glycine max*, *Brassica*

**Corresponding author:* Vinoth Kumar K
Assistant Professor, Faculty Centre for Agricultural Education and Research, RKMVERI, Coimbatore-20

oleracea and *Daucus carota*). The inhibition of root elongation was observed in all plant species with uncoated alumina nanopaticles. Limited phytotoxicity studies reported both positive and negative effects of nanoparticles on higher plants. Hence, the present study was carried out to investigate the effect of ZnO nanoparticles on root growth and root anatomy of maize plant.

MATERIALS AND METHODS

In order to assess the effect of metal oxide nanoparticles on plant growth pot culture experiment was carried. Soil was collected and dried under shade, powdered with wooden mallet. Then the soil was passed through 2 mm sieve to remove pebbles, roots and debris. After processing, one kg of soil was transferred to each pot and required nutrients were added. Based on the treatments, ZnO nanoparticles were added to each pot and thoroughly mixed for 15 min. Two maize seeds were sown in pots of each replication. The plants were watered once in two days. The experiment was conducted for 35 days (upto vegetative stage) with seven treatments and three replications (Fig.1).

Treatment Details

T_1 - Control (without nanoparticles)
T_2 - Nano ZnO - 100 mg kg^{-1} of soil
T_3 - Nano ZnO - 500 mg kg^{-1} of soil
T_4 - Nano ZnO - 1000 mg kg^{-1} of soil
T_5 - Nano ZnO - 2000 mg kg^{-1} of soil
T_6 - Nano ZnO - 5000 mg kg^{-1} of soil
T_7 - Nano ZnO - 10000 mg kg^{-1} of soil

Fig 1 Pot culture experiment

Root Anatomical Study

The maize plant from different treatments was harvested at 35 DAS and root was removed and rinsed with distilled water. The root tissues was cut into a small pieces measuring 4 to 5 mm length and fixed in a mixture of 5 parts of 35 per cent formalin, 5 parts of glacial acetic acid and 90 parts of ethyl alcohol (FAA) fixative for 24 h. The tissues were then dehydrated using a series of baths consisting of water, ethyl alcohol and tertiary butyl alcohol and embedded in wax. The thin sectioning was done using rotary microtome and the sections were placed on slides previously coated with Haupt's adhesive. The wax was removed by passing the slides gently through xylol for 10 min and rehydrated in a series of baths consisting of xylol (100 per cent), xylol + ethanol (50+50 per cent) and ethanol (100 per cent). The slides were kept in each bath for 10 min and stained with saffranin and viewed under Nikon light microscope (10x) with image processor.

RESULTS AND DISCUSSION

The surface area of the ZnO nanoparticles was measured to be 15 to 25 m^2 g^{-1}. The molecular weight of the particle was 81.39. The typical SEM image shown the particles are predominately spherical in shape with the size of 20 to 85 nm (Fig. 2).

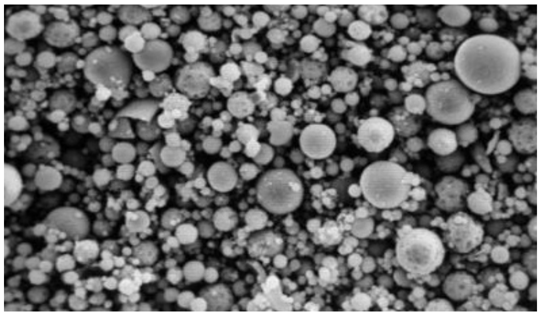
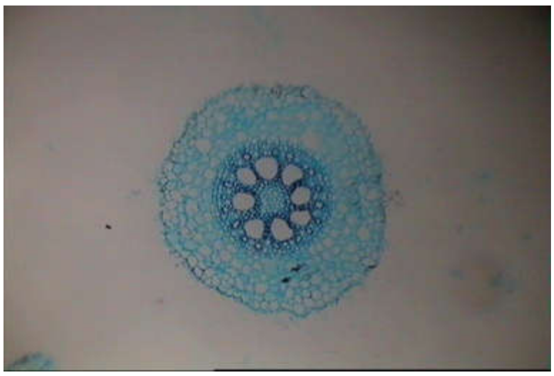
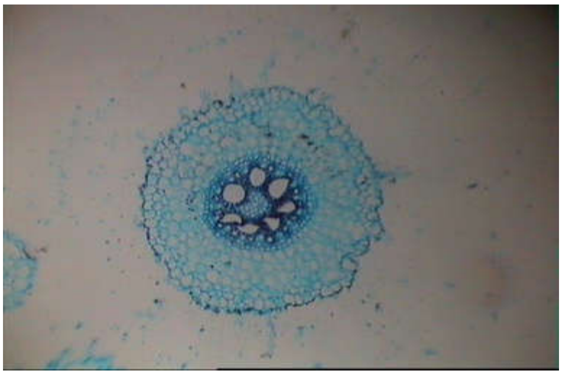


Fig 2 SEM image of ZnO nanoparticles

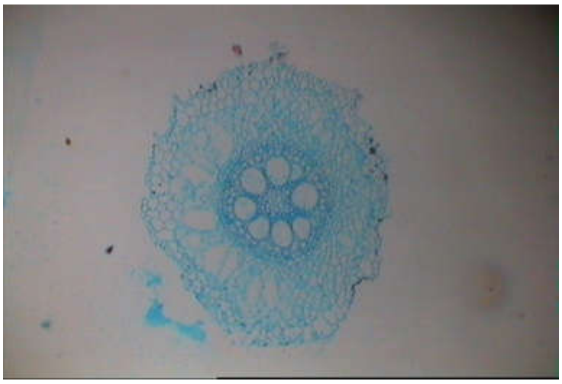
The root anatomy picture of maize plant grown under different concentrations of ZnO nanoparticles is shown in Fig. 3. The variation was observed in the root anatomy structure of maize at higher concentration of ZnO nanoparticles. Maize plant comes under the monocotyledons and roots are having basic tissue system of epidermis, cortex and vascular cylinder. Presence of higher concentrations of ZnO nanoparticles affected the anatomical structure of maize. The root of maize plant grown under control (without nanoparticles), 100, 500 and 1000 mg of nano ZnO kg^{-1} of soil found to be undisturbed and root was developed very well with the usual three tissue systems of epidermis, cortex and vascular cylinder. However, shrunken morphology of maize root was observed under the treatment of 2000, 5000 and 10000 mg of nano ZnO kg^{-1} of soil. The root cap and epidermis of the root were broken, the cortical cells were highly vacuolated and collapsed and the vascular cylinder also shrunken. No living cells in the root tips could be observed in the presence of ZnO nanoparticles at higher concentrations. The similar phenomenon was observed by Lin and Xing (2008) in their study to find out the effect of ZnO nanoparticles on the growth of ryegrass. They reported that the presence of 1000 ppm of ZnO nanoparticles was affecting the anatomical structure of ryegrass and also observed the shrunken morphology of root.



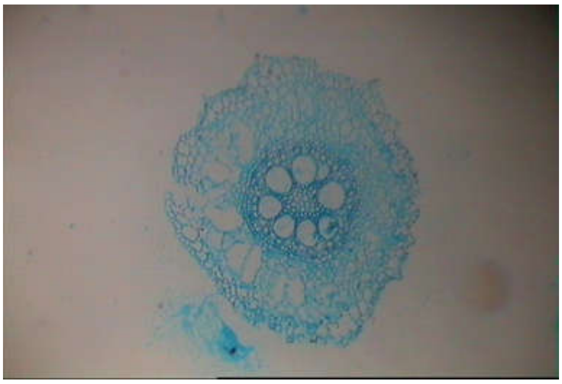
T_1 - Control (without nanoparticles)



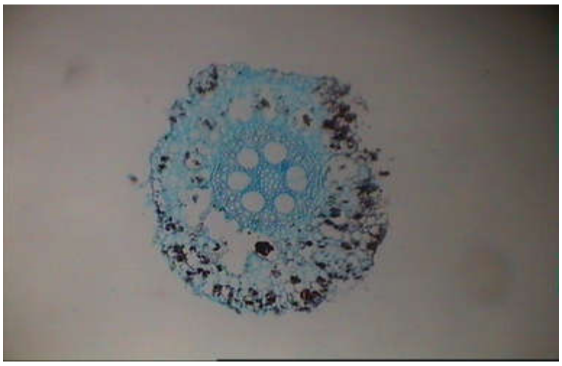
T_2 - Nano ZnO - 100 mg kg^{-1} of soil



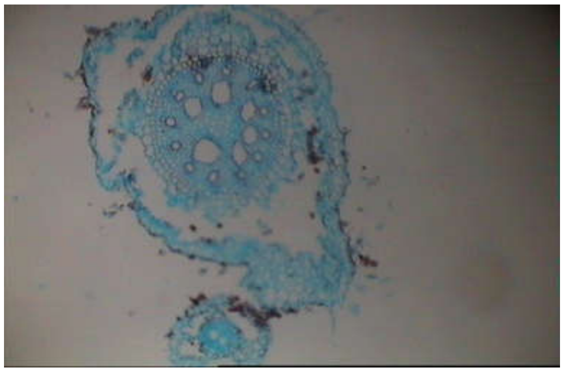
T_3 - Nano ZnO - 500 mg kg^{-1} of soil



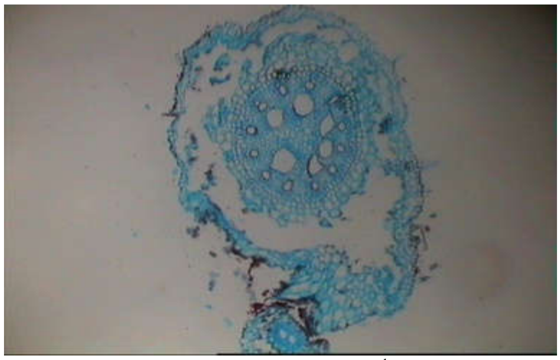
T_4 - Nano ZnO - 1000 mg kg^{-1} of soil



T_5 - Nano ZnO - 2000 mg kg^{-1} of soil



T_6 - Nano ZnO - 5000 mg kg^{-1} of soil



T_7 - Nano ZnO - 10000 mg kg^{-1} of soil

Fig 3 Effect of ZnO nanoparticles on root anatomical structure of maize plant

CONCLUSION

The presence of higher concentrations of ZnO nanoparticles significantly influenced the root growth of maize crop. The highest toxic effect and root damage was observed under the 10000 mg of nano ZnO kg^{-1} of soil followed by 5000 and 2000 mg of nano ZnO kg^{-1} of soil. Engineered nanoparticles could potentially lead to an unexpected environmental hazard. Therefore, organisms and especially those that interact strongly with their immediate environments are expected to be affected as a result of their exposure to engineered nanoparticles.

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