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Nanofertilizers in Seed Priming and Foliar Applications of Nanomaterial on Plant Growth and Development

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SUMMARY

Fertilizers were applied in agriculture for many years to the benefit of farmers. Traditional fertilisers are not only costly, but they are also damaging to humans and the environment. As a result, environmentally friendly fertilisers with high nutrient value and compatibility with soil and environment are required. Nanotechnology, in the form of nanofertilizers, is emerging as a promising alternative for improving the quality qualities of crops. A nanofertilizer is made up of nanoformulations of nutrients that are delivered to plants in a way that allows for prolonged and uniform absorption.

INTRODUCTION

Although measured in terms of the energy required for its synthesis, tonnage consumed, and monetary worth, nitrogen, which is a critical nutrient source for food, biomass, and fibre production in agriculture, is by far the most important element in fertilisers. However, crops' nitrogen usage efficiency (NUE) is quite poor when compared to the amount of nitrogen delivered to the soil. Between 50 and 70% of nitrogen applied with conventional fertilisers plant nutrient formulations with dimensions greater than 100 nm is lost due to leaching in the form of water soluble nitrates, emission of gaseous ammonia and nitrogen oxides, and long-term incorporation of mineral nitrogen into soil organic matter by soil microorganisms1 Numerous attempts to raise the NUE have largely failed, and the time may have arrived to use nanotechnology to overcome some of these issues.

Recently, carbon nanotubes were discovered to penetrate tomato seeds, and zinc oxide nanoparticles were shown to enter ryegrass root tissue (Fig. 1).

This shows that new nutrient delivery systems can be created that take advantage of nanoscale porosity domains on plant surfaces. Reduced research funding and a lack of clear rules and innovation policies may have hampered the potential use of nanotechnology to improve fertiliser formulations. In comparison to medicines, the usage of nanotechnology in fertiliser production is still very modest (approximately 100 patents and patent applications between 1998 and 2008). (more than 6,000 patents and patent applications over the same period).

A nanofertilizer is a nutrient-delivery device that works in one of three ways. The nutrition can be enclosed inside nanomaterials like nanotubes or nanoporous materials, coated with a thin polymer film, or administered as nanoscale particles or emulsions. Nanofertilizers may outperform even the most inventive polymer-coated traditional fertilisers, which have experienced no development in the last ten years, due to their high surface area to volume ratio. Nanotechnology might, in theory, provide devices and procedures to coordinate nitrogen release (from fertilizers).

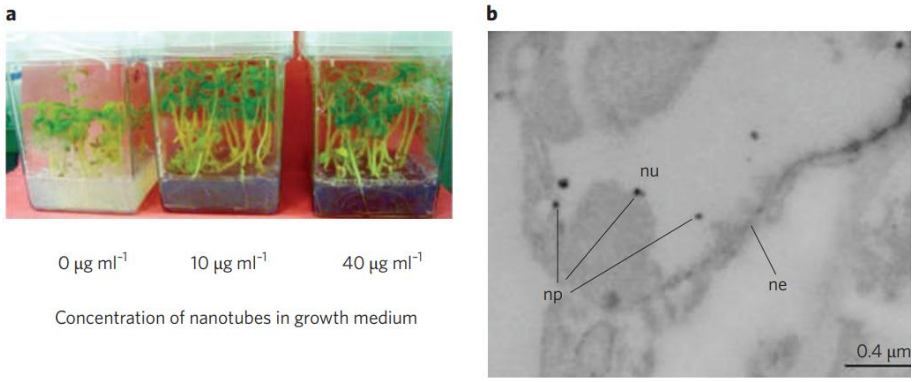

Figure 1 | Plants can be impacted by nanomaterials. a, Improved growth of 27-day-old tomato seedlings cultured in a carbon nanotube-containing media. (2009 ACS) is reprinted with permission. b, Transmission electron micrograph of ryegrass roots revealing zinc oxide nanoparticles entering the nucleus (nu, nucleus; ne, nuclear envelope; np, nanoparticles). Adapted with permission from ref (ACS, 2008).

With crop production, nanofertilizers should release nutrients on-demand while preventing them from changing prematurely into chemical/gaseous forms that are indigestible to plants. This can be accomplished by keeping nutrients from interacting with soil, water, or microorganisms, and only releasing nutrients when the plant can directly internalise them. Nanostrategies are starting to appear as examples.

The regulated release of chemical substances that regulate plant growth has been achieved using zinc–aluminiumlayered double-hydroxide nanocomposites. Fertilizers mixed into cochleate nanotubes have been claimed to improve yields (rolled-up lipid bilayer sheets). The insertion of urease enzymes into nanoporous silica has been used to limit the release of nitrogen from urea hydrolysis.

These techniques are intriguing, but they lack mechanisms to recognise and respond to plant demands as well as changes in soil nitrogen levels. The creation of functional nanoscale films and devices has the potential to boost NUE and agricultural productivity significantly. Nanotechnology may be able to improve the efficacy of fertilisers in other ways besides raising the NUE. Nanosize titanium dioxide, for example, has been used as a bactericidal ingredient in fertilisers due to its photocatalytic properties. Furthermore, the photoreduction of nitrogen gas by titanium dioxide may lead to increased crop yield. In addition, nanosilica particles absorbed by roots have been demonstrated to create coatings at cell walls, which can boost the plant's stress tolerance and yields. By improving fertiliser products, nanotechnology has the potential to have a significant impact on energy, the economy, and the environment. New opportunities for incorporating nanotechnologies into fertilisers should be investigated, while keeping in mind any potential risks to the environment or human health. We believe that nanotechnology will be transformative in this arena if governments and universities work together to build such enabled agri products.

Advance application in Nano-fertiliser application

Fig: Drone spraying of Nano Urea was successfully tested in the field

A realistic field experiment of Drone Spray of Nano Liquid Urea was done at Bhavnagar, Gujarat, in the presence of Union Minister of Chemicals and Fertilizers and Health and Family Welfare Shri Mansukh Mandaviya. A significant number of farmers attended the trial. IFFCO, a nano urea developing business, conducted this demonstration of delivering liquid nano urea by drone. The programme was hailed as a big success by Union Minister Shri Mandaviya. "India is becoming the world's first country to begin commercial Nano Urea production." Nano Urea is not only being produced on a huge scale now, but farmers have been embracing it on a vast scale since the beginning. It began production in June and has produced over 5 million bottles of Nano Urea to date. Every day, more over one lakh bottles of nano urea are manufactured," he stated.

Seed priming is the technique of controlling germination by adjusting the temperature and moisture content of the seed to maximise its potential. Several distinct priming procedures, such as liquid or osmotic priming and solid matrix priming, have been reported to be utilised commercially. Micronutrients can be used as seed priming material. A new strategy for increasing seedling vigour and increasing germination percentage is nano priming of elements (Dehkourdi and Mosavi, 2013; Ghafari and Razmjoo, 2013).

This method is very useful in chelate fertilisers like zinc, calcium, and iron. These micronutrients can also be applied to the leaves as a foliar treatment. Foliar application is a method of feeding plants that involves directly delivering liquid micronutrients to their leaves. Essential nutrients can be absorbed by plants through their leaves. Nanofertilizers enhanced peanut output and photosynthesis, according to Liu *et al.* (2005). Sheykhbaglou *et al.* (2010) found that spraying nano fertilisers like nano-iron oxide particles on the leaves boosted soybean grain yield. Nano zinc particles were found to boost stem and root growth in other studies.

Seed priming had a significant influence solely on 100 seed weight and grain yield, while foliar treatment had a substantial effect on grain yield and yield components. Grain yield and yield components were unaffected by the interplay of foliar spray and seed priming (data not shown). The nano-iron chelate fertiliser raised seed number per pod, pod number per plant, 100 seed weight, and grain production by 17, 48, 13, and 65 percent, respectively, as compared to the control treatment.

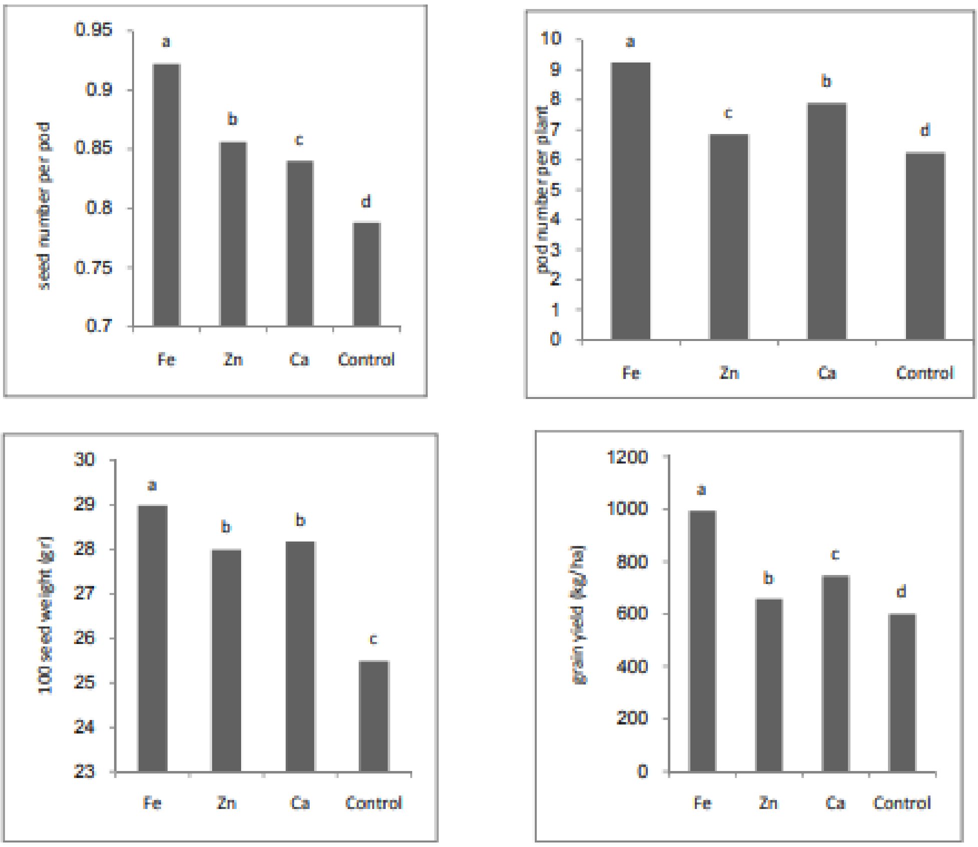

Fig. 1. Effect of foliar application of nanoparticles on grain yield and yield components.

According to Hatwar *et al.*, stated that there is increased photosynthetic and other metabolic activities leads to an increase in various plant metabolites responsible for cell division and elongation, which leads to an increase in various plant metabolites responsible for cell division and elongation (2003). Iron is a component of ferrodoxin, an electron transport protein that is associated with chloroplast, and it plays an important function in improving growth characteristics. It may have aided in better growth because it aids in photosynthesis (Hazra *et al.*, 1987). Using iron fertiliser enhanced chickpea grain production by 17.3 percent over the control. Iron foliar treatment enhanced grain yield through altering the quantity of seeds per plant and seed weight.

As a result, iron shortage may be a production limiting factor, lowering crop yield dramatically. Seed priming with Zn, Fe, and Ca nanoparticles increased 100 seed weight and grain yield as compared to the untreated control (Fig. 2). The rapid and appropriate establishment of seedlings (Farooq *et al.*, 2008), minimization of time between seed sowing and emergence and emergence synchronisation (Parera and Cantliffe, 1994), their capable use of nutrient, soil moisture, and solar radiation (Subedi and Ma, 2005), photosynthetic rate and stomatal conductance (Subedi and Ma, 2005), and photosynthetic rate and stomatal conductance (Fariduddin *et al.*, 2003).

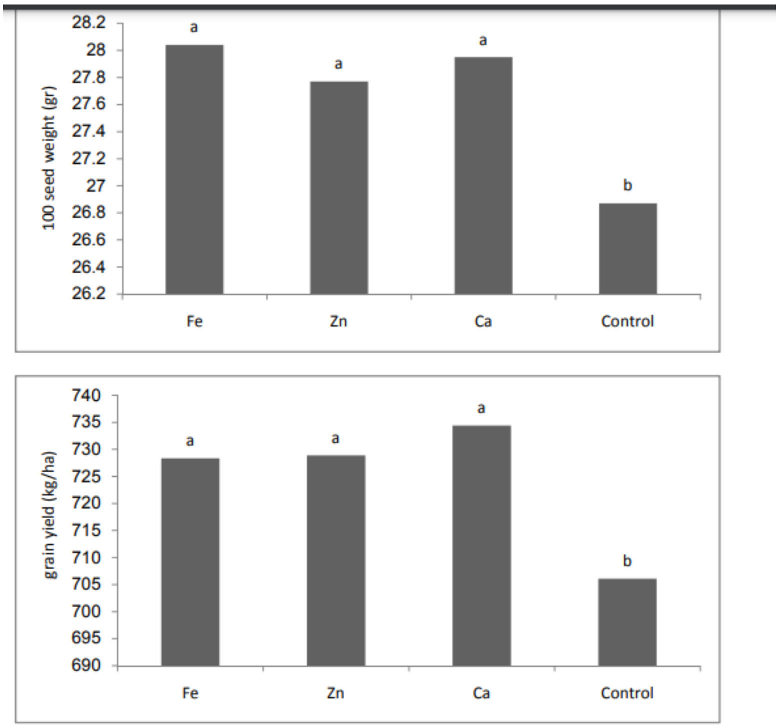

Fig. 2. Effect of seed priming with nanoparticles on grain yield and 100 seed weight.

Nano iron treatment has an effect on a protein produced by a bean plant. The introduction of iron nanoparticles appears to result in an increase in pod number and seed weight per 100 seeds.

CONCLUSION

Climate change, resource depletion, and biodiversity loss are all threatening our agriculture. A new agricultural revolution is required to improve crop yield while also ensuring food quality and safety in a sustainable manner. Agriculture's long-term viability can be aided by nanotechnology. The significant use of nano-ZnO as a seed polymer coating/priming treatment improved the fodder maize's vegetative growth, fodder output and fibre quality. Furthermore, ZnONPs coating or priming treatments were found to be more effective at increasing the available zinc micronutrient in a field-grown fodder maize crop. Thus, seed treatments with a little amount of ZnO nanofertilizer can assist reduce zinc fertiliser application doses and, as a result, conventional Zn-fertilizer waste. Nano-priming affects biochemical pathways as well as the balance of reactive oxygen species and plant growth hormones, promoting stress and disease resistance while reducing pesticide and fertiliser use. The current study gives an overview of recent developments in the sector, highlighting the problems and opportunities associated with using nanotechnology in seed nano-priming as a contribution to sustainable agriculture practises.

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