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Editorial

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Nanoparticles as novel plant growth promoters

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Introduction

Crop plants are prone to infection by several pathogens which cause diseases that affect the production and economy of these crops. Farmers tend to use traditional control methods such as; chemical pesticides and bioagents which are non-ecofriendly and not easily produced/ applied, respectively. Nanoparticles (NPs) have sizes less than 100 nm and are considered for several applications including; agriculture, food technology, pharmaceuticals in addition to protection of environment (Chakravarty *et al*., 2015). Availability, low-cost and non-phytotoxicity of NPs are the main prerequisites for their application in the field of agriculture.

Shankramma *et al*., (2016) added that crop production can be considerably enhanced by the use of suitable growth promoting substances such as nanofertilizers. Recently, Liu *et al*., (2016) suggested that engineered nanofertilizers can be manipulated for effective utilization of some soil nutrients by the plant such as inorganic phosphorous (P) and water to increase crop productivity. Consequently, this will reduce applications of synthetic fertilizers and prevent pollution of ecosystem. Mousavi Kouhi *et al*., (2015); Mukherjee *et al*., (2016) studies reported that application of NPs at low concentration stimulate seed germination and increase growth rate in many crop plants. These enhanced growth and development of plants are due to the interaction between plant cells and the NPs that leads to change in biochemical reactions responsible for regulating gene expression.

Zinc (Zn) is a micronutrient essential for plant growth, as it is an important component of many enzymes responsible for several metabolic reactions in plants. Zn controls the synthesis of the phytohormone indole acetic acid (IAA) responsible for regulating plant growth. It is also required for chlorophyll synthesis and formation of carbohydrates (Vitosh *et al*., 1994). Moreover, improvement of Zn nutritional status also reduces the uptake of phytotoxic heavy metals such as Cadmium (Cd) (Adiloglu, 2002). Venkatachalam *et al*., (2017) study focused on applying zinc oxide nanoparticles (ZnONPs) carrying phycomolecule ligands as novel plant growth promoters to increase crop production. This investigation examined the effect of ZnONPs on growth characteristics of cotton (*Gossypium hirsutum* L.) and associated biochemical changes, following growth in a range of concentrations of ZnONPs (25-200 mg/l) in presence of 100 mM of (P). Cotton plants increased in growth and total biomass by

130.6% and 131%, respectively, compared with control. Moreover, considerable increase in the level of chlorophyll a (141.6%), b (134.7%), carotenoids (138.6%), and total soluble proteins (179.4%) were recorded; in addition to significant reduction (68%) in the level of malondialdehyde (MDA) in cotton leaves. These promising results could be attributed to the interaction of bioengineered ZnONPs with cotton meristematic cells thus stimulated biochemical reactions that led to increase of biomass.

Earlier studies of Zheng *et al*., (2005); Yang *et al*., (2006) recorded that Titanium dioxide nanoparticles (TiO2 NPs) enhanced nitrogen metabolism and photosynthesis in spinach, thereby improving its growth when supplied at a suitable low concentration. Recently, Abdel Latef *et al*., (2018) evaluated the effects of three different concentrations of TiO2 NPs (0.01%, 0.02% and 0.03%) on improving growth of broad bean grown under stress of saline soil. Application of TiO2 NPs at 0.01% under normal soil conditions increased shoot length; leaf area and dry weight of broad bean root. Growth promoting effects were associated with increased levels of chlorophyll b, proline and soluble sugars, in addition to enhanced activities of antioxidant enzymes. However under saline soil conditions without NPs, although proline level and activities of antioxidant enzymes were increased; however plant growth was considerably retarded. Supplementation of TiO2 NPs at 0.01% promoted broad bean growth, increased the activities of antioxidant enzymes, levels of soluble sugars, proline and amino acids in salt-affected plants compared with control. This was attributed to the reduction in hydrogen peroxide and malondialdehyde contents with increased antioxidant enzymes activities. Meanwhile, enhanced levels of proline and amino acids led to osmoprotection, resulting collectively in significant improvement in plant growth under soil salinity. TiO2 NPs at 0.02% showed an intermediate response, whereas, 0.03% was ineffective under control and saline soil conditions.

Mustafa *et al*., (2015) reported that silver nanoparticles (AgNPs) were beneficial to the growth of soybean exposed to flooding. Proteomic analysis confirmed that soybeans would suffer less when treated with AgNPs in the absence of oxygen. Accordingly, under flooding conditions plants would have their development much better by the reactive oxygen species (ROS) generated by nanosilver. Pallavi *et al*., (2016) investigated the effect of AgNPs on the growth of wheat (*Triticum aestivum*), cowpea (*Vigna sinensis*), and Brassica (*Brassica juncea*) at three different concentrations (0, 50 and 75 mg/l) applied through foliar spray. After harvesting, shoot and root growth parameters were compared. AgNPs caused no significant effect on the growth parameters of wheat plant, however, at 75 mg/l they caused negative impact on root fresh weight and root length. In cowpea, 50 mg/l of AgNPs enhanced the growth and induced an increase in root nodulation, whereas in Brassica, 75 mg/l concentration improved shoot parameters only with no observed effect on root growth.

Similarly, Madbouly *et al*., (2017) reported that AgNPs caused appreciable enhancement in the growth parameters of tomato seedlings including; root, shoot fresh weight, and height of seedlings in soil infested with pathogenic *Fusarium oxysporum* compared with the control soil, under greenhouse conditions. Moreover, AgNPs reduced the severity of wilt symptoms by 90% observed through decreasing the number of wilted tomato seedlings after placing their roots in a suspension of AgNPs (500 mg/l) for 4h prior to soil infestation with *F. oxysporum*.

NPs have both promoting and phytotoxic effects on growth and development of most plants at low and high concentrations, respectively. The phytotoxicity of Ag on barley plant (*Hordeum vulgare* L.) subjected to Ag as $AgNO_3$ and AgNPs was examined by Fayez *et al*., (2017). Grain germination and growth of barley seedlings decreased in the presence of 0.1 mM of Ag and was inhibited at higher concentration of 1 mM Ag. In contrast, AgNPs at low concentration (0.1 mM) enhanced barley grain germination and seedling growth, this might be attributed to increased activities of some enzymes. However, higher concentrations of these AgNPs (0.5 and 1 mM) had negative effect on grain germination and caused significant reduction in root length. These effects might be attributed to penetration of both Ag and AgNPs to parenchyma cells of the grain and then were transported to the embryo and seedlings cells. Moreover, Ag and AgNPs increased malondialdehyde contents, phenolic compounds, soluble proteins and activity of guaiacol peroxidase in barley leaves; suggesting activation of barley defence response against oxidative stress.

According to Jasim *et al*., (2017), high levels of AgNPs activate the aminocyclopropane-1-carboxylic acid (ACC) which inhibits root elongation in Arabidopsis seedlings. Venkatachalam *et al*., (2017) added that NPs phytotoxicity arises because of the hazardous substances coating the surface of these chemically synthesized NPs. Therefore, bio-synthesized NPs should be used in agriculture.

In conclusion, biosynthesized NPs could be manipulated as novel and available plant growth promoters especially when used at low concentrations, in spite of using traditional expensive chemical fertilizers. However, further studies are required before using these NPs on a wide scale in the field, because their accumulation on the long run in the soil and underground water resources is non-ecofriendly, phytotoxic and may also affect the balance of microbiota in the soil.

References

Abdel Latef, A.A.H.; Srivastava, A.K.; Abd El-sadek, M.S.; Kordrostami, M. and Tran, L.S.P. (2018). Titanium dioxide nanoparticles improve growth and enhance tolerance of broad bean plants under saline soil conditions. Land Degradation and Development. 29: 1065-1073.

Adiloglu, A. (2002). The effect of zinc (Zn) application on uptake of cadmium (Cd) in some cereal species. Archives of Agronomy and Soil Science. 48: 553–556.

Chakravarty, D.; Erande, M.B. and Late, D.J. (2015). Graphene quantum dots as enhanced plant growth regulators: effects on coriander and garlic plants. Journal of the Science of Food and Agriculture. 95: 2772-2778.

Fayez, K.A.; El-Deeb, B.A. and Mostafa, N.Y. (2017). Toxicity of biosynthetic silver nanoparticles on the growth, cell ultrastructure and physiological activities of barley plant. Acta Physiologiae Plantarum. 39: 155.

Jasim, B.; Thomas, R.; Mathew, J. and Radhakrishnan, E.K. (2017). Plant growth and diosgenin enhancement effect of silver nanoparticles in Fenugreek (*Trigonella foenum-graecum* L.). Saudi Pharmaceutical Journal. 25: 443-447.

Liu, R.; Zhang, H. and Lal, R. (2016). Effects of stabilized nanoparticles of copper, zinc, manganese, and iron oxides in low concentrations on lettuce (*Lactuca sativa*) seed germination: nanotoxicants or nanonutrients. Water, Air, and Soil Pollution. 227: 42.

Madbouly, A.K.; Abdel-Aziz, M.S. and Abdel-Wahhab, M.A. (2017). Biosynthesis of nanosilver using *Chaetomium globosum* and its application to control *Fusarium* wilt of tomato in the greenhouse. IET Nanobiotechnology. 11(6): 702-708.

Mousavi Kouhi, S.M.; Lahouti, M.; Ganjeali, A. and Entezari, M.H. (2015). Comparative effects of ZnO nanoparticles, ZnO bulk particles and Zn^{2+} on *Brassica napus* after long-term exposure: changes in growth, biochemical compounds, antioxidant enzyme activities, and Zn bioaccumulation. Water, Air, and Soil Pollution. 226: 364.

Mukherjee, A.; Sun, Y.; Morelius, E.; Tamez, C.; Bandyopadhyay, S.; Niu, G.; White, J.C.; Peralta-Videa, J.R. and Gardea-Torresdey, J.L. (2016). Differential toxicity of bare and hybrid ZnO nanoparticles in green pea (*Pisum sativum* L.): a life cycle study. Frontier Plant Science. 6, 1242.

Mustafa, G.; Sakata, K.; Hossain, Z. and Komatsu, S. (2015). Proteomic study on the effects of silver nanoparticles on soybean under flooding stress. Journal of Proteomics. 122: 100-118.

Pallavi, Mehta, C.M.; Srivastava, R.; Arora, S. and Sharma, A.K. (2016). Impact assessment of silver nanoparticles on plant growth and soil bacterial diversity. Biotechnology. 6: 254.

Shankramma, K.; Yallappa, S.; Shivanna, M.B. and Manjanna, J. (2016). Fe_2O_3 magnetic nanoparticles to enhance *S. lycopersicum* (tomato) plant growth and their biomineralization. Applied Nanoscience. 6(7): 983-990.

Venkatachalam, P.; Priyanka, N.; Manikandan, K.; Ganeshbabu, I.; Indiraarulselvi, P.; Geetha, N.; Muralikrishna, K.; Bhattacharya, R.C.; Tiwari, M.; Sharma, N. and Sahi, S.V. (2017). Enhanced plant growth promoting role of phycomolecules coated zinc oxide nanoparticles with P supplementation in cotton (*Gossypium hirsutum* L.). Plant Physiology and Biochemistry. 110: 118-127.

Vitosh, M.L.; Warncke, D.D. and Lucas, R.E. (1994). Secondary and micronutrients for vegetable and field crops, Michigan State University extension bulletin E-0486.

Yang, F.; Hong, F.; You, W.; Liu, C.; Gao, F.; Wu, C. and Yang, P. (2006). Influence of nano-anatase TiO2 on the nitrogen metabolism of growing spinach. Biological Trace Element Research. 110:179-190.

Zheng, L.; Hong, F.; Lu, S. and Liu, C. (2005). Effect of nano-TiO2 on strength of naturally aged seeds and growth of spinach. Biological Trace Element Research. 104: 83–91.