

# Novel inclusion of engineered nanoparticles in horticultural sectors

## Abstract

Nanoparticles, which are omnipresent in the environment, make their easy way within living systems where their effect can be positive, negative, or neutral. A positive result on plants shows better germination rate and plant growth whereas negative result exhibits growth inhibition, cell damage or deterioration, etc. All these phenomena depend upon the plant species, types of nanoparticles, the concentration of the nanoparticles as well as the nature of the medium. Understanding the nature of interactions between engineered nanoparticles and plants is crucial in the comprehension of the impact of nanotechnology on the environment and agriculture with a focus on toxicity concerns, plant disease treatment, and genetic engineering. In this perspective, the effect of engineered nanoparticles on horticultural plant species will enrich our knowledge about the benefits or risks of these nanoparticles on the balance of the ecosystem namely their mobility, reactivity, toxicity, and persistency in the living system as well as to open a new era to involve different nanoparticles in crop production and overall management of agricultural techniques in near future.

**Keywords:** horticultural plant species, crop production, genetic engineering

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## Applications of nanoparticles in horticulture

In recent decade different engineered nanoparticles (ENPs) are used in a variety of biological systems like fluorescent biological labels,<sup>1</sup> gene and drug delivery,<sup>2,3</sup> bio-detection of pathogens,<sup>4</sup> detection of proteins,<sup>5-7</sup> probing of DNA structure and in tissue engineering.<sup>8-10</sup> Nowadays various ENPs are also widely used in agricultural purposes as nano-fertilizers (NFs), nano-pesticides, nano-herbicides, nano-sensors, etc.<sup>11-15</sup> Increasing market demand and commercial value of chemical fertilizer catch interest on the scientist to prepare a modified, targeted, NFs which are eco-friendly and much facile for plants to take up and can be modified to be time-released.<sup>16-18</sup> During the design of NFs beside plant protection and nutrients, one should keep in mind the side effect of these ENPs on the environment as all the ENPs used to prepare NFs are finally released in our ecosystem.

NFs enters within the plant system through stomal opening, lenticels, and root system and enhance the overall nutrient use efficiency (NUE).<sup>19</sup> Nano-agrochemicals also create attentions to agriculturist for their positive effect on hydroponic plant culture.<sup>20</sup> However, NFs have some advantages over chemical fertilizers and nano-agrochemicals. Alternative to chemical fertilizer, NFs required in very low amounts, easy to use, cost-effective, high nutrient use efficiency, supply macro, and micronutrients which usually soil lacks.<sup>21</sup> The most popular ENPs used recently as NFs are carbon nanotube (CNTs), zinc nano fertilizer, nanoporous zeolite, boron nano, etc. Among all other ENPs, the Penetration capability of CNTs through hard seed coat enhances the germination percentage, shoot growth, and overall crop plant biomass production.<sup>22,23</sup> The bioavailability and bio-degradation capability of CNTs also make their wide use in NFs production.<sup>24,25</sup>

ENPs can be used to prepare pesticides, herbicides, fungicides for securing crop production and are more beneficial than conventional plant protection techniques that have been used in large-scale and in over-dose.<sup>26</sup> Nano herbicide and nano pesticides are also much effective in crop plants than the market available insecticide killers.<sup>27,28</sup>

At present agricultural practices, nano-agrochemicals are very common as the emerging category of contaminants generates a negative impact on field crops. Alternatively, an emerging solution has developed by involving nanotechnology to prepare nano pesticides and NFs.<sup>29</sup> Moving to a broader concept of nano-enabled technology and building on the experience from other sectors (e.g., food science, nanometrology) will be more valuable to support the development of more sustainable agrochemicals.<sup>20</sup> NFs have more availability to plants as they can enter easily through the nano-pores and stomatal openings in plant leaves. The deep insertion of ENPs within the plant body leads to higher nutrient use efficiency (NUE).<sup>30</sup> The higher NUE and lesser nutrient loss of NFs lead to 5-17% higher productivity and also improve the nutritional quality of horticultural crops.<sup>31</sup>

Some ENPs also can enhance stress tolerance capability that sometimes helps farmers to produce crops in the adverse situation also.<sup>32</sup>

Very recently green synthesized ENPs are also involved in horticultural sectors because of their eco-friendly nature and easy to process compared to the other routes of ENPs synthesis.<sup>33,34</sup>

Some ENPs viz. oxidized multiwalled carbon nanotubes (OMCNTs), hydroxyapatite NPs (HAP), gold NPs, silver NPs, etc. are directly interacted with seeds of vegetables or flowering plants and remarkably enhance seed germination rate, overall plant growth and biomass production.<sup>35,36</sup>

Nanosensor-based global positioning system (GPS) is now popularly used throughout the seasons for real-time monitoring of cultivated fields globally.<sup>37</sup>

## Pros & cons

The applications of ENPs in horticultural sectors have raised many positive impacts and also some risk factors. Positive results include three times increase in nutrient use efficiency (NUE), 80-100 times less requirement to chemical fertilizers, 10 times more stress-tolerant

by the crops, Complete bio-sourced, so eco-friendly, 30% more nutrient mobilization by the plants and 17-54% improvement in the crop yield.<sup>20,21</sup> For monitoring the controlled release mechanism in the cultivated fields, the network of wireless nano-sensors is very helpful and cost-effective also.

Minute dose with the presence of more active ingredients in nano-formulated plant protective samples not only protect plants against pests but also enhance subsequent crop loss.<sup>38-41</sup> However, all the ENPs related treatment are dose-dependent. An extra dose may cause germination hindrance, reduction in plant growth, and overall crop production directly and also health hazards like tissue damage, high blood pressure, gastrointestinal problems, etc. to the consumers indirectly.<sup>42-44</sup> Though ENPs are used in minute concentration the mishandling of preparations and long-term use may cause the release of ENPs in the environment causing environmental pollution to some extent such as water, soil, and air pollution.<sup>42</sup>

## Concluding remarks

While ENPs are being used in a variety of ways to tackle bio-related issues, a possible area of wide ramification is being neglected due to a lack of relevant technology and understanding. The use of nanoparticles in agricultural sectors has been explored by researchers a few years ago and very recently its implementation in the horticultural sectors improves the production rate of vegetables, flowers, and other essential crop plants to meet the huge demand of the growing population.

Interactions between plants and nanoparticles deserve a more in-depth investigation on many fronts, such as uptake potential of different plant species, mechanisms of uptake, translocation, and the interactions between the particles with plant tissue at the cellular level. However, soon, the exploration of various ENPs in horticultural sectors encourages farmers to a green revolution with negligible farming risks and insignificant side effects.

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## Conflicts of interest

The authors have no conflicts to declare.

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