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Review Article

Role of nanotechnology in improving quality of edible crop plants

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ABSTRACT

Improving human health is the considered major concern in area of medical and agricultural sciences. It is achieved by providing good health supplements with balanced diet to people in the forms of cost effective and safe nano-biofortified or nano-bioengineered vegetable crop plants to fight against malnutrition and other various diseases. And these nano-based methodologies are involved the use of nanoparticles of essential nutrients like copper, iron, selenium, cobalt, and zinc being as fertilizers or stimulants in soils or waters to improve the qualities of vegetable crop plants and make them more enriched with major nutrients and diseased free. Hence, this strategic clinical and agro-practice based management should be considered to combat fungal and microbial diseases of crop plants through cost effective and green nanotechnology-based approach used in the form of nano-formulation and fortified bioagents and biostimulants.

1. Introduction

Human health is major global concern and interests have been risen for the implementation of green and cost effective nanoscience driven technologies to enhance the quality of edible crop plants. It was done for enhancing their essential nutrients to be used as nutraceuticals, antioxidants, antimicrobial ingredients in foods supplement and enhancing flavors.[1–3] Nano-formulation of antimicrobial plant growth promoting thymol containing nanoemulsion was also prepared by using Quillaja saponin, a glycoside surfactant of Quillaja tree.[4–6] Past plant studies have been proposed for developing bioagents to replace chemical bactericides to be used against plant diseases like tomato bacterial wilt, Kimchi cabbage soft rot, and red pepper bacterial leaf spot to boost plant immunity in respective edible crop plants which commonly caused by gram-negative and gram-positive bacteria named, *Dickeya* and *Pectobacterium* (soft-rot bacterial plant pathogens). These nano based approaches are also reported for improving edible crop plants to minimize the post-harvest losses and early fruit ripening which occurred due to known bacterial and fungal diseases like bacterial spot, caused by *Xanthomonas campestris*; bacterial speck, caused by *Pseudomonas syringae*; and bacterial canker, caused by *Clavibacter michiganensis*, tomato target leaf spot caused by *Corynespora cassiicola*, tomato early blight caused by *Alternaria solani*.[7–9] These potent antimicrobial green nanoformulations were found to have excellent storage capacity and antimicrobial to be used as bioagents for reducing occurrence of wilt effectively with combination of fluorescent *Pseudomonas* and *T. harzianum* by 74% and 67% in pots and field, respectively.[10–12]

2. Brief Potential Payoff Matrix of Nanotechnology

The incorporation of health nutrients into edible crop plants in nano concentration is called nano-biofortification including boron, copper, iron, iodine, calcium, selenium and zinc nanoparticles to supplement human diet with

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balanced diet to combat human malnutrition.[13–15] Green preparations were used to prepare biofortified foods and feed by synthesizing selenium nanoparticles, iron nanoparticles using leaves of *Ocimum basilicum* and green tea; Copper-nanoparticles of *Eucalyptus globulus*, zinc oxide-nanoparticles from *Nilgiriantusciliantus* leaf, nickel oxide-nanoparticles of *Nigella sativa* seeds and magnesium oxide-nanoparticles.[16,17] These bio-engineered nanoparticles could be considered as good health supplements like food additives or food industry like colorants, flavor enhancers, and artificial sweeteners.[17–19] The positive effects of these bio-nanoengineered plant based preparations were found to promote plant enzymes like nitrate reductase, phosphatase, amylase, and phytase and used to enhance biosynthesis of chlorophyll and photosynthetic activities in edible vegetable crop plants. Zinc oxide nanoparticles are found to have influence on the Cadmium uptake by plants which have strong impact on wheat.[20]

3. Green Aspect

Green preparation of high quality and non-toxic nanoparticles especially in consideration of having chemical purity, phase selectivity, crystallinity, and homogeneity in particle size with controlled state of agglomeration must be first choice for material chemists and bioengineers. High quality magnesium oxide (MgO) nanoparticles have been explore to study fate of nanoparticles in various environmental remediation stakes linked to the human health.[20–22] Use of copper oxide nanoparticles was also explored in improving crop plant quality and their conservation to observe beneficial effects in seedlings, enhancing plant growth and the involvement of nitric oxide signalling in the phytotoxic effects.[23,24] Agricultural soils have found to improve by the use of nanoparticles-based fertilizers to achieve nano-biofortification by promoting structural alterations, modifying gene expression, and improving antioxidant defence systems by enhancing the nutrient utilization efficiency and decrease environmental problems.[25,26] Many biophysiochemical parameters have been studied for regulating uptake, translocation and distribution of nanoparticles in crop plants by fortification process which defines mode of application like aerial/foliar, root and seed priming also includes interactions with other environmental components like microbiota, soil water, soil surface and soil structure.[27,28]

4. Conclusion

Nanotechnology is found to be considered advanced tool to prepare biofortified foods or dietary supplements and also improving the nutritional quality of vegetable crop plants by the use of nanofertilizers or nanobiostimulats. Characteristics of food nutrients based nanoparticles and overall non-toxic uptake of nano-based nutritional components in edible crop plants were found to be their green and cost effective outcome in respective payoff matrix of nanotechnology approaches. Hence, in this urban scientific era, the various nanotechnology based practices in food and agricultural industries have vast scope adin the environment especially soil-plant systems, human exposure becomes inevitable through direct touching or via edible plant tissues causing hazardous health impacts.

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6. Conflict of Interest

The authors declare no relevant conflicts of interest.

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References

1. Das AK, Nanda PK, Bandyopadhyay S, Banerjee R, Biswas S, McClements DJ, et al. Application of nanoemulsion-based approaches for improving the quality and safety of muscle foods: A comprehensive review. *Compr Rev Food Sci Food Saf.* 2020;19(5):2677–700. doi:10.1111/1541-4337.12604.
2. Suciati T, Satrialdi AA. Development of transdermal nanoemulsion formulation for simultaneous delivery of protein vaccine and Artin-M-Adjuvant. *Int J Pharm Pharm Sci*;6(6):536–46.
3. Takegami S, Uchida S, Aoi E, Yamamoto T, Yashuara A, Fujihara M, et al. Effect of bovine serum albumin on stability of biocalutamide-encapsulated lipid-nano-emulsion in bovine serum albumin. *Current Nanosci*. 2015;8(2):187–92. doi:10.2174/157341312800167579.
4. Wang T, Lin J, Chen Z, Megharaj M, Naidu R. Green synthesis of Fe nanoparticles using Eucalyptus leaf extracts for treatment of eutrophic wastewater. *Sci Total Environ*. 2014;466-467:210–3. doi:10.1016/j.scitotenv.2013.07.022.
5. Kumari S, Kumaraswamy RV, Choudhary RC, Sharma SS, Pal A, Raliya R, et al. Thymol nanoemulsion exhibits potential antibacterial activity against bacterial pustule disease and growth promotory effect on soybean. *Sci Rep*. 2018;8(1):6650. doi:10.1038/s41598-018-24871-5.
6. Júnior JBT, Rezende R, Itako AT, de Freitas P, Frizzone JA. Drip fungigation in early blight control of tomato. *Acta Scientiarum Agronomy*. 2011;33(1):9–14. doi:10.4025/actasciagron.v33i1.9515.
7. Le KD, Kim J, Yu NH, Kim B, Lee C, Kim J, et al. Biological Control of Tomato Bacterial Wilt, Kimchi Cabbage Soft Rot, and Red Pepper Bacterial Leaf Spot Using Paenibacillus elgii JCK-5075. *Front Plant Sci*. 2020;11:775. doi:10.3389/fpls.2020.00775.
8. Charkowski AO. The changing face of bacterial soft-rot diseases. *Annu Rev Phytopathol*. 2018;56:269–88. doi:10.1146/annurev-phyto-080417-045906.
9. Salim HA, Salman IS, Jasim BN. IPM Approach for the Management of Wilt Disease caused by Fusarium oxysporum f. sp. lycopersici on Tomato (Lycopersicon esculentum). *J Exp Biol Agricultural Sci*. 2016;4(VIS):742–7. doi:10.18006/2016.4(VIS).742.747.
10. Shoda M. Bacterial control of plant diseases. *J Biosci Bioeng*. 2000;89(6):515–21. doi:10.1016/S1389-1723(00)80049-3.
11. Rani K. Green synthesis of antimicrobial nanosuspensions of Platanus orientalis. *Adv Tissue Eng Regen Med* . 2019;5(1):21–2. doi:10.15406/atroa.2019.05.00094.

12. Sharma RK, Patel DR, Chaudhari DR, Kumar V, Patel MM. Effect of Some Fungicides against Early Blight of Tomato (Lycopersicon esculentum Mill.) Caused by Alternaria solani (Ell. & Mart.) Jones and Grout and Their Impact on Yield. *Int J Curr Microbiol App Sci*. 2018;7(07):1395–401. doi:10.20546/ijcmas.2018.707.166.
13. Srivastava R, Khalid A, Singh US, Sharma AK. Evaluation of arbuscular mycorrhizal fungus, fluorescent Pseudomonas and Trichoderma harzianum formulation against Fusarium oxysporum f. sp. lycopersici for the management of tomato wilt. *Biol Control*. 2010;53(1):24–31.
14. Abinaya S, Kavitha PH, Prakash M, Muthukrishnaraj A. Green synthesis of magnesium oxide nanoparticles and its applications: a review. *Sustain Chem Pharm*. 2021;19:100368. doi:10.1016/j.scp.2020.100368.
15. Deng J, Ding QM, Jia MX, Li W, Zuberi Z, Wang JH, et al. Biosafety risk assessment of nanoparticles: evidence from food case studies. *Environ Pollut*. 2021;275:116662. doi:10.1016/j.envpol.2021.116662.
16. El-Ramady H, Singh A, Rajput VD, Amer M, Omara AE, Elsakhawy T, et al. Environment, biodiversity and soil security: a new dimension in the era of COVID-19. *Environ Biodivers Soil Secur*. 2021;5(2021):1–14. doi:10.21608/JENVBS.2021.55669.1125.
17. Fajardo C, anchez Fortún SS, Costa G, Nande M, Botías P, García-Cantalejo J, et al. Evaluation of nanoremediation strategy in a Pb, Zn and Cd contaminated soil. *Sci Total Environ*. 2020;706:136041. doi:10.1016/j.scitotenv.2019.136041.
18. Ganie AS, Bano S, Khan N, Sultana S, Rehman Z, Rahman MM, et al. Nanoremediation technologies for sustainable remediation of contaminated environments: recent advances and challenges. *Chemosphere*. 2021;275:130065. doi:10.1016/j.chemosphere.2021.130065.
19. González-García Y, Cárdenas-Álvarez C, Cadenas-Pliego G, Benavides-Mendoza A, Cabrera-De-La-Fuente M, Sandoval-Rangel A, et al. Effect of three nanoparticles (Se, Si and Cu) on the bioactive compounds of bell pepper fruits under saline stress. *Plants*. 2021;10(2):1–16. doi:10.3390/plants10020217.
20. Munir H, Mumtaz A, Rashid R, Najeeb J, Zubair MT, Munir S, et al. Eucalyptus camaldulensis gum as a green matrix to fabrication of zinc and silver nanoparticles: characterization and novel prospects as antimicrobial and dye-degrading agents. *J Mater Res Technol*. 2020;9(6):15513–24. doi:10.1016/j.jmrt.2020.11.026.
21. Pelegrino MT, Kohatsu MY, Seabra AB, Monteiro LR, Gomes DG, Oliveira HC, et al. Effects of copper oxide nanoparticles on growth of lettuce (Lactuca sativa L.) seedlings and possible implications of nitric oxide in their antioxidative defense. *Environ Monit Assess*. 2020;192(4):232. doi:10.1007/s10661-020-8188-3.
22. Prerna DI, Govindaraju K, Tamilselvan S, Kannan M, Vasantharaja R, Chaturvedi S, et al. Influence of nanoscale micronutrient α-Fe2O3 on seed germination, seedling growth, translocation, physiological effects and yield of rice (Oryza sativa) and maize (Zea mays). *Plant Physiol Biochem*. 2021;162:564–80. doi:10.1016/j.plaphy.2021.03.023.
23. Rizwan M, Ali S, Ali B, Adrees M, Arshad M, Hussain A, et al. Zinc and iron oxide nanoparticles improved the plant growth and reduced the oxidative stress and cadmium concentration in wheat. *Chemosphere*. 2019;214:269–77. doi:10.1016/j.chemosphere.2018.09.120.
24. Sharma D, Shandilya P, Saini NK, Singh P, Thakur V, Saini RV, et al. Insights into the synthesis and mechanism of green synthesized antimicrobial nanoparticles, answer to the multidrug resistance. *Mater Today Chem*. 2021;19:100391. doi:10.1016/j.mtchem.2020.100391.
25. Silva LFO, Santosh M, Schindler M, Gasparotto J, Dotto GL, Oliveira MLS, et al. Nanoparticles in fossil and mineral fuel sectors and their impact on environment and human health: a review and perspective. *Gondwana Res*. 2021;92:184–201. doi:10.1016/j.gr.2020.12.026.
26. Tiozon RN, Fernie AR, Sreenivasulu N. Meeting human dietary vitamin requirements in the staple rice via strategies of biofortification and post-harvest fortification. *Trends Food Sci Technol*. 2021;109:65–82. doi:10.1016/j.tifs.2021.01.023.
27. Yu Z, Yang Y, Wang C, Shi G, Xie J, Gao B, et al. Nano-soy-protein microcapsule-enabled self-healing biopolyurethane-coated controlled-release fertilizer: preparation, performance, and mechanism. *Mater Today Chem*. 2021;20:100413. doi:10.1016/j.mtchem.2020.100413.
28. Zahedi SM, Moharrami F, Sarikhani S, Padervand M. Selenium and silica nanostructure-based recovery of strawberry plants subjected to drought stress. *Sci Rep*. 2020;10:17672. doi:10.1038/s41598-020-74273-9.

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