Short Communication



# Notch sight review on use of antimicrobial nano preparations as immunity agro-booster for production of diseased free *Solanum tuberosum* crop plant

## Abstract

*Solanum tuberosum* (potato plant) vegetable crop is used worldwide in various industries like food & beverage industries and pharmaceutical industries. Its potential improved agricultural production can be helpful to combat the global hunger index of many underdeveloped and developing countries. But production is getting hampered due to various reasons such as post-harvest losses, early ripening and moreover because of few bacterial and fungal diseases such Bacterial wilt, Septoria leaf spot, Late blight, Early blight, Common scab, Black scurf/ canker caused by *Clavibacter michiganensis.* Currently there is a growing interest in the study of nano dispersions due to its bioavailability and biocompatibility that found to report which destabilized the lipid membrane of the pathogenic microbes due to their potent antimicrobial activity. As well as, their nano sized droplets will likely increase transport efficiency of any kind of loaded chemical or biological molecules to the targeted sites which also imparted antimicrobial resistance to crop plant especially potato plants. Managing the plant pathogenesis through various green and sustainable herbal nanopreparations can be observed satisfactory for the environmental concerns and cost effectiveness especially for autumn winter tomato which face the decrease in production either early flowing and fruiting period or post-harvest loss due to attack of fungal and bacterial pathogens.

**Keywords:** *Solanum tuberosum,* potato plant, vegetable crop plant, immunity booster, nano suspensions

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## Introduction

*Solanum tuberosum* (potato plant) vegetable crop has become one of the most popular crop plant globally and it is also an economical food as major source of human diet.[1,2] Potatoes are enriched with good amount of starch, ascorbic acid and vitamin B which used in various wood, textile, paper and pharmaceutical industries as bioactive binder and bioactive agents.[3,4] Vast growing interests have been proposed earlier for their implementation of innovative nanoscience-mediated technologies to develop nano formulations. Nano dispersions are nano sized non-toxic lipid droplets whose permeation is found to be reported faster in biological surfaces due to their considerable volatility due to having surfactant treated bound lipids.[5] Field study was conducted in red & lateritic soil of Regional Research Station, Jhargram, Bidhan Chandra Krishi Viswavidyalaya, West Bengal (India) to evaluate the growth response of potato crop against foliar application of macro and micronutrients. Foliar application of mixture of Zn, B, Fe, Mn and NPK, T8-Control was sprayed with NPK (19:19:19) that resulted in highest potato tuber yield when compared with control field yield.[6] It is proposed for delivery systems for various essential nutrients, required nutraceuticals, antioxidants, antimicrobial ingredients in foods supplements, imparting colors and enhancing flavors along with improved quality, safety and nutritional profile.[7] Nanosized antibacterial plant growth promoting thymol containing nanoemulsion was also formulated by using *Quillaja* saponin, a glycoside surfactant of *Quillaja* tree.[8] A green approach was used to prepare iron oxide and manganese dioxide nanoparticles by using *Beta vulgaris* leaf extract which was proposed to be used as nano fertilizer to study *In-vitro* micro tuberization of potato. This studied interaction of the used nanoparticles with the nodal explants was led to significantly induce early tuber induction and tuber growth. Molecular analysis of potato tissues was also done that confirmed the enhanced expression of primary tuber inducing genes; Calcium-Dependent Protein Kinases (StCDPK); Calmodulin (StCaM1); and Lipoxygenase (*StLOX*) enzyme activity. Hence, this discrete study was revealed that use metal-oxide based nanoparticles as nano fertilizer led to increase potato microtuber production.[9] Repeated and regular exposure of chemical bactericides has led to ill effects, on exposed plant like residual toxicity and bacterial pathogen resistance and also caused environmental pollution as well. Management of plant pathogenesis through bactericides is the only satisfactory cost effective and sustainable solution. Nano fertilizers were found to have sustainable potential to fulfill to improve potato crop plant by increasing plant nutrition requirements. The proposed trials were conducted on standing potato crop plant by applying 2 sprays of nano-nitrogen in standing crops gave that resulted in higher yields than FFP.[10]

## Reacquaint previous approaches proposed for various crop/vegetable plants

Varius findings in last decades have been proposed to produce biological agents to replace chemical based bactericides which were used to reduce plant pathogenesis. The antibacterial activity of prepared thymol nanoemulsion (0.01–0.06%, v/v) was studied by growth inhibition analysis that confirmed antibacterial efficacy against *Xanthomonas axonopodis pv. cyamopsidis* (18–0.1 log CFU/ml). It was found that foliar spray of the different concentration of

thymol nanoemulsion (0.01–0.06%, v/v) improved the percent efficiency of disease control of cluster beans up to 95% by reducing disease intensity of bacterial blight. An antimicrobial plant based nanoemulsion was formulated for plant growth that was prepared by using thymol, an essential oil component of named *Quillaja* saponin; type of glycoside surfactant of *Quillaja* tree.[11–13] The fermentation broth of *P. elgii* JCK-5075, at 5-fold dilution, effectively suppressed the development of tomato bacterial wilt, Kimchi cabbage soft rot, and red pepper bacterial leaf spot in pot experiments with control values of 81, 84, and 67%, respectively. PGP-A and C, at 200 µg/ml, were also found to markedly reduce the development of Kimchi cabbage bacterial soft rot by 75% and tomato bacterial wilt by 83%, respectively, and their disease control efficacy was comparable to that of oxolinic acid with control values of 81 and 85%, respectively. Additionally, the antibacterial activity of PGP-C was found to be directly correlated with membrane damage mechanisms. These results indicates that *P. elgii* JCK-5075 producing PGPs could be used as a biocontrol agent for the control of plant bacterial diseases. This is the first report on the in vitro and in vivo antibacterial activity of PGPs against bacterial plant pathogens. Bacterial soft rot is a disease complex caused by multiple genera of gram-negative and gram-positive bacteria, with *Dickeya* and *Pectobacterium* being the most widely studied soft-rot bacterial pathogens. In addition to soft rot, these bacteria also cause blackleg of potato, foot rot of rice, and bleeding canker of pear.[13,14] Pheroid nutrient delivery method was developed with nanostructured $FePO_4$ to synthesize novel Fe foliar fertilizers that were used for foliarly application on fieldcrop soybeans in Northern Cape (South Africa) to study their impact on seed nutrient composition and production yield.[14,15] Various studies have been listed out in given table (Table 1) which were proposed earlier to study applications of synthesized metallo-nano-biofortifications to improve crop/vegetable plants production index including agricultural economics index.[16–22]

**Table 1** Previously reported study of metallo-nano-bio fortifications in various proposed crop/vegetable plants[16–22]

| S. No. | Functionality | Name of nanoparticles | Crop plant | References no. |
|---|---|---|---|---|
| 1 | Nano-treatment led to increased yield by 27% and protein content | Nano chelated iron fertilizer | Paddy rice (*Oryza sativa* L.) | Fakharzadeh et al., 2020[16] |
| 2 | Fe-NPs increased chlorophyll under Cadmium stress by using seed priming method | Fe-NPs immunity booster (50-100 nm) | Wheat (*Triticum aestivum* L.) | Rizwan et al., 2019[17] |
| 3 | Applied Se-NPs increased ascorbate concentration (31.5%) followed by reduced glutathione (35%) | Se-NPs (10–45 nm) | Chicory (*Cichorium intybus* L.) | Abedi et al., 2021[18] |
| 4 | Applied Se/$SiO_2$ at 100 mg $L^{-1}$ can helpful to manage harmful impacts of soil drought stress via higher level of osmolytes like proline and carbohydrate | Se-NPs (25 mg $L^{-1}$, 60 nm) | Strawberry (*Fragaria×ananassa* Duch) | Zahedi et al., 2020[19] |
| 5 | Improved yield and essential oil production of seeds | Se-NPs (10–30 nm) | Groundnut (*Arachis hypogaea* L.) | Hussein et al., 2019[20] |
| 6 | Se-NPs at 10 mg $L^{-1}$ recorded the highest yield and improved quality of fruits | Se-NPs (2–20 nm) | Tomato (*S. lycopersicum* L.), saladette "El Cid F1 | Hernández-Hernández et al., 2019[21] |
| 7 | Nano based treatment led to enhanced the maturity index and decreased cracking of fruits | $Na_2SeO_4$ and Se-NPs (10–45 nm) | Pomegranate: *Punica granatum* L. cv. Malase Saveh | Zahedi et al., 2019[22] |

## Sustainable approaches suitable to improve Solanum tuberosum crop plant production index

Green synthesis of non-toxic nanoparticles with good crystallinity, improved phase selectivity, high percent of chemical purity and excellent homogeneity in particle size distribution with potent agglomeration that must be first choice for biochemists and bioengineers. Improved quality of magnesium oxide (MgO) nanoparticles have been proposed to study for applications of nanoparticles in various environmental remediation processes which considered for betterment of human kind.[23,24] In last decades, copper oxide based nanoparticles was used to improve crop plant quality followed with conservation to study their role in improving seedlings and plant growth.[25] Agricultural soil was found to improve by nanoparticles-produced by green methods that used as agro-fertilizers for nano-bio fortification. So that, it led to modification in gene expression to improve antioxidant defence systems to utilize soil nutrients efficiently by decreasing environmental stress for better yield of vegetable crop plants.[26–28] A comparative study was proposed to study foliar application of NPK nano fertilizers at recommended level ranging from 50% or 25% that was showed higher values of economic yield (23.59-ton ha−1) and starch concentration rate of 79.62%, NPK nutrient use efficiency (67.74, 278.92, 118.54 kg potato/kg nutrient), harvest index (59.24%). It has been observed that foliar application of 50% of NPK nano fertilizers was found to be the most economical treatment that gave highest potato yield by improving quality along with achieving good and acceptable profit with respect to its cost ratio of potato production.[29] The increase in potato yield production and quality attributes in foliar nano fertilizer applied treatments might be due to nano-NPK promotes plant to absorb water and nutrients, yet improved photosynthesis, where nano-NPK are considered the biological pump for plants to absorb water and nutrients increasing harvest index which resulted in increased biomass and yield production.[30] Foliar application of NPK nano fertilizers was proposed to enhance Egyptian potato yield production and its quality that further followed by decreasing the cost of fertilization and environmental hazards.[31] Hence, the use of nano fertilizers is found to be more potent and sustainable alternatives over conventional chemical fertilizers. These degradable nano-polymer based fertilizers were showed slow and more efficient targeted release as per crop requirements during plant growth cycle/phase to confirm respective fertilizer use efficiency.[32]

## Conclusion and future prospective

The antifungal and antimicrobial activity of nano dispersion/nanoemulsion is considerably to have potential to deliver loaded chemical or biological components peptides which are prone to enzymatic hydrolysis and other expected oxidation. Earlier,

various prepared nano formulations are found to be non-toxic and biodegradable in contrary to metals/nanoparticles that will be further useful for achieving effective delivery system for antimicrobial activity to inhibit the growth of microbial strains in controlled manner.[33,34] The major limiting factors in various vegetable crop plant production are biotic stresses due to infection caused by various microbes including nematodes, viroids and pests including abiotic stress which makes agricultural production uneconomical due to loss in pre-harvest period.[15] Therefore, suitable management is needed to be introduced for controlling various microbial pathogenesis of potato crop plant through effective integrated and sustainable approach using nano formulation can be cost effective and safe alternative to combat various fungal and bacterial diseases. So, many biophysiochemical parameters could might be proposed to study the regulating uptake, translocation and distribution of sustainable and cost effective nanoparticles in *Solanum tuberosum* (potato plant) by fortification process which includes mode of use like seed priming, root and foliar. This would be remarkable pin-point to improve potato plant crop production via studying biotic an abiotic plant metabolic interactions with considered environmental factors like soil microbiome, soil hydration, soil basic nutrient composition and soil porosity.[9,29]

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## Conflicts of interest

The author declares that there are no conflicts of interest.

## References

1. Das AK, Nanda PK, Bandyopadhyay S, 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):2677–2700.
2. Kumari A, Rana V, Yadav SK, et al. Nanotechnology as a powerful tool in plant sciences: recent developments, challenges and perspectives. *Plant Nano Biol*. 2023;5:100046.
3. Lourerio A, Abreu AS, Saria MP, et al. Functionalized protein nanoemulsion by incorporation of chemically modified BSA. *RSC Adv*. 2015;5:4976–4983.
4. Suciati T, Aliyandi A, Satrialdi. Development of transdermal nanoemulsion formulation for simultaneous delivery of protein vaccine and artin–M adjuvant. *Int J Pharma Pharma Sci*. 2014;6(6):2014.
5. Takegami S, Uchida S, Aoi E, et al. Effect of bovine serum albumin on stability of biocalutamide-encapsulated lipid nano-emulsion in bovine serum. *Curr Nanosci*. 2015;8(2):187–192.
6. Moinuddin G, Jash S, Sarkar A, et al. Response of potato (*Solanum tuberosum* L.) to foliar application of macro and micronutrients in the red and lateritic zone of West Bengal. *J Crop Weed.* 2017;13(1):185-188.
7. Rani K. Emulsified entrapment of glycine max B–amylase into chemically modified bovine serum albumin and study its applications in detergents. *Int J Adv Biotechnol Res*. 2012;3(2):591–595.
8. Wang T, Lin J, Chen Z, et al. Green synthesis of Fe nanoparticles using Eucalyptus leaf extracts for treatment of eutrophic wastewater. *Sci Total Environ*. 2014;466–467:210–213.
9. Joshi N, Pathak A, Upadhyaya NC, et al. Synthesis of biocompatible $Fe_3O_4$ and $MnO_2$ nanoparticles for enhanced tuberization in potato (*Solanum tuberosum* L.). *Biocatalysis Agri Biotechnol*. 2022;39:102258.
10. Tiwari KN, Kumar Y, Nayak RK, et al. Nano-urea for enhancing yield and farmers profit with potato in Uttar Pradesh. *Ann Plant Soil Res*. 2021;23(4):495–500.
11. Kumari S, Kumaraswamy RV, Choudhary RC, et al. Thymol nanoemulsion exhibits potential antibacterial activity against bacterial pustule disease and growth promotory effect on soybean. *Sci Rep*. 2018;8(1):6650.
12. Gill T, Li J, Saenger M, et al. Thymol-based submicron emulsions exhibit antifungal activity against *Fusarium graminearum* and inhibit fusarium head blight in wheat. *J Appl Microbiol*. 2016;121(4):1103–1116.
13. Pan K, Chen H, Davidson PM, et al. Thymol nanoencapsulated by sodium caseinate: physical and antilisterial properties. *J Agri Food Chem*. 2014;62(7):1649–1657.
14. Cakmak I. Enrichment of cereal grains with zinc: agronomic or genetic biofortification? *Plant Soil*. 2008;302:1–17.
15. Knijnenburg JTN, Hilty FM, Oelofse J, et al. Nano and pheroid technologies for development of foliar iron fertilizers and iron biofortification of soybean grown in South Africa. *Chem Biol Technol Agri*. 2018;5:26..
16. Fakharzadeh S, Hafizi M, Baghaei MA, et al. Using nanochelating technology for biofortification and yield increase in rice. *Sci Rep*. 2020;10(1):4351.
17. Rizwan M, Ali S, Ali B, et al. Zinc and iron oxide nanoparticles improved the plant growth and reduced the oxidative stress and cadmium concentration in wheat. *Chemosphere*. 2019;214:269–277.
18. Abedi S, Iranbakhsh A, Ardebili ZO, et al. Nitric oxide and selenium nanoparticles confer changes in growth, metabolism, antioxidant machinery, gene expression, and flowering in chicory (*Cichorium intybus* L.): potential benefits and risk assessment. *Environ Sci. Pollut Res.* 2021;28(3):3136–3148.
19. Zahedi SM, Moharrami F, Sarikhani S, et al. Selenium and silica nanostructure- based recovery of strawberry plants subjected to drought stress. *Sci Rep*. 2020;10(1):17672.
20. Hussein HA, Darwesh OM, Mekki BB, et al. Evaluation of cytotoxicity, biochemical profile and yield components of groundnut plants treated with nano–selenium. *Biotechnol Rep (Amst)*. 2019;24:e00377.
21. Hernández HH, Gutiérrez TQ, Pliego GC, et al. Impact of selenium and copper nanoparticles on yield, antioxidant system, and fruit quality of tomato plants. *Plants* (Basel). 2019;8(10):355.
22. Zahedi SM, Hosseini MS, Meybodi NDH, et al. Foliar application of selenium and nano-selenium affects pomegranate (*Punica granatum* cv. *Malase Saveh*) fruit yield and quality. *South Afr J Bot*. 2019;124:350–358.
23. Sayed SFE, Hassan HA, Mogy MME. Impact of bio and organic fertilizers on potato yield, quality and tuber weight loss after harvest. *Potato Res*. 2015;58:67–81.
24. Sharma RK, Patel DR, Chaudhari V, et al. 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(7):1395–1401.
25. Rani K. Green synthesis of antimicrobial nanosuspensions of *Platanus orientalis*. *Adv Tissue Eng Regen Med Open Access*. 2019;5(1):21–22.
26. Yadav OP, Dabbas MR. Efficacy of fungicides in the management of early blight of tomato (*Alternaria solani*). *Int J Plant Prot*. 2012;5(2):413–416.
27. Asit KM, Praveen KM, Subrata D, et al. Effective management of major tomato diseases in the gangetic plains of eastern India through integrated approach. *Agri Res Tech Open Access J*. 2017;10(5):555796.
28. Srivastava R, Khalid A, Singh US, et al. 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.

29. El-Azeim MMA, Sherif MA, Hussien MS, et al. Impacts of nano and non–nanofertilizers on potato quality and productivity. *Acta Ecol Sinica*. 2020;40(5):388–397.

30. Singh MD, Chirag G, Prakash PO, et al. Nano-fertilizers is a new way to increase nutrients use efficiency in crop production. *Int J Agri Sci*. 2017;9(7):3831–3833.

31. Sohair EED, Abdall AA, Amany AM, et al. Effect of nitrogen, phosphorus and potassium nano fertilizers with different application times, methods and rates on some growth parameters of Egyptian cotton (*Gossypium barbadense* L.). *Biosci Res*. 2018;15(2):549–564

32. Tarafdar JC, Raliya R, Mahawar H, et al. Development of zinc nanofertilizer to enhance crop production in pearl millet (*Pennisetum americanum*) *Agric Res J*. 2014;3(3):257–262.

33. Rani K, Chauhan C. Preparation of *Cicer artienium* amylase loaded BSA nanoparticles and their bioproteolysis to be used as detergent additive. *Bioeng Biosci*. 2015;3(5):73–82.

34. Rani K. Role of nanotechnology in improving quality of edible crop plants. *IP Int J Compr Adv Pharmacol*. 2022;7(3):112–114.

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