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Comparative Analysis of effect of Nanoparticles Synthesized by Chemical and Green Methods on Seed Germination: A Review

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ABSTRACT: Nanoparticles (NPs) have different applications because of their special physical and chemical properties. The chemical method of nanoparticle synthesis is difficult due to its toxicity while the green route is considered ecofriendly. Different studies and experiment's data give the information about the properties exerted by the nanoparticles. All plants / seeds uptake their nutrients from nature but in some severe conditions we provide them with extra nutrients from outside to prevent their loss during seed germination process.The paper consists various data about the requirement of nanoparticles, their applications, the hazardous effects of the nanoparticles, various methods of preparation of nanoparticles via their synthesis, the advantages and the disadvantages of the nanoparticles based on their synthesis, the effects of various nanoparticles on the seed germination and it includes the analyzed data of effect of nanoparticles like zinc, copper, titanium, silver and iron synthesized through green and chemical approaches on the germination of seed. The nanoparticles synthesized by the chemical method may show some phytotoxicity due to the excessive use of chemicals during their production; this may give a slight edge for the green synthesized nanoparticles to use in severe conditions.

Keywords: Green synthesis, chemical synthesis, ecofriendly, nanoparticles, toxins, germination, hazardous

INTRODUCTION

Nanotechnology is one of the emerging and fast-growing fields of science and it is also the sixth revolution technology after industrial revolution (mid1700s), Nuclear energy evolution (1940s), green revolution (1960s), Information technology (1980s) and biotechnology (1990s). The term nanotechnology was invented by Norio Taniguchi in 1974 (a professor at the Tokyo University of Science) which means extra-high precision and ultra-fine dimensions. There are wide ranges of applications for Nanoparticles in different fields such as electronics, biotechnology, agriculture and in various other fields. If we lower the size to less than 100nm in at least one dimension it can change the physical and chemical properties of a substance. (Suraj *et al.,* 2016) mentioned in their review paper that Nanotechnology is developing and becoming great method of generating nanoparticles for more benefits. Nanotechnology must be secured for the future as per its applications and advantages. The products produced by the technology of nanoparticles are growing exponentially. Green synthesis via the plant mediated method is considered cost-effective, simple, rapid and eco-friendly regardless of its low production of the NPs. By replacing the chemical fertilizers with the nano fertilizers in order to deliver various micro and macro nutrients to the plant through soil gradually decreases the amount of chemicals and pollutants in the soil which can make it more fertile and can increase the yield of the plant. Biological polyphosphates like ATP, DNA and RNA can be manipulated using the magnesium ions (Shinde *et al.,* 2011) as the magnesium plays an important role in many plant processes like plant respiration, photosynthesis and energy metabolism. Nanoparticles can improve the efficiency of microorganism in degradation of waste and toxic materials. Nano encapsulated pesticides show the slow releasing properties with the enhanced permeability and stability. The properties of nanoparticles usually depend on the surface characteristics, crystal structure and size. The characterization of nanoparticles can be done by using the spectroscopy, which measures the particles interaction with electromagnetic radiation as a function of wave length (Hassellov *et al.,* 2008). In the current developments of multidisciplinary sciences like physics, chemistry, biology and engineering nanoparticles have been widely used which are produced by humans or by the nature. The metals with Nanometric dimensions have been used by Romans in glass-making. Nanoparticles of silver and gold have been used in the famous Lycurgus cup (exhibited at the British Museum), it displays different color based on how it is illuminated either externally (green) or internally (red). The majority of the part of applications are still unknown and yet to be found. The enhancement of nanoparticles can help solve questions in many fields of science and may also lead to the environmentally friendly nature of anthropogenic lifestyle as, the major pollutants can also be eradicated by the proper use of the nanoparticles.

Need for nanoparticles. Nanoparticles have many applications from various fields of the development, they are used in agriculture, bio-medical imagining,

medical and in several other fields. Properties of the materials change when they are formed from the nanoparticles, as nanoparticles have greater surface area per weight than larger particles it makes them more reactive than other molecules. The modification of the gene expression and alteration of genetic pathways using the nanoparticles given to the plant can affect the growth and development of the plant. In every branch of medicine nanoparticle have drawn an increasing interest as they have the ability to deliver drugs in optimum doses which results in higher therapeutic efficiency of the drugs with weakened side effects (Alexis *et al.,* 2008). As effective drug delivery devices bio-degradable nanoparticles are gaining considerable interest in past few decades (Zhang and Saltzman, 2013). Titanium oxide nanoparticles have increased the rate of germination of seed to prime in parsley seeds (Dehkourdi *et al.,* 2013). By the addition of silver nanoparticles some plant species inhibited the seed germination but in some other species it showed beneficial effect on growth of plant it enhanced the germination rate and in growth of corn, watermelon and zucchini seeds (Almutairi *et al.,* 2015). Photosynthetic parameters have been found to be increased by the addition of citrate coated iron oxide nanoparticles (Alidoust *et al.,* 2013). So, in modern era of development the nanoparticles have the major role in enhancing the technology in many fields of science and engineering.

Problems to focus. Nanoprticles can also impact negatively by natural means or through anthropogenic activities such as Smoking or building demolitions, engine exhaust and indoor pollution etc. Some studies have also shown that aluminum nanoparticles have an impact on the Alzheimer's disease (Buzea *et al.,* 2007). Cellular processes can also get influenced by the nanoparticles as they have small size. The ability to terminate the root growth is present in zinc and zinc oxide nanoparticles (Behboudi *et al.,* 2017). Excess of copper oxide nanoparticles can lead to root necrosis and inhibition of root growth which are important for uptake of nutrients (Adhikari *et al.,* 2012). Silver nanoparticles with size less than 50nm are proven to be very toxic to *Vicia faba* seedlings and did not affect germination rate (Abdel-Azeem *et al.,* 2013). The size of the nanoparticles is inversely proportional to the aberrant cells and the rate of aberrant cells was directly proportional to the duration of exposure. Moreover, the toxicity of nanoparticles also depends on many factors like its chemical composition and the chemicals which are adsorbed into its surface. So, the excessive use of nanoparticles can also lead to the negative impact on the plant germination or in any other case.

Approach of green and chemically synthesized nanoparticles

Chemical approach. The Chemical methods of nanoparticles synthesis are the most ordinary technique engaging the reduction of metal salt by utilizing numerous chemicals reducing agents (Elemike *et al.,* 2020). The most frequently utilized reducing agents include dimethyl amine borane, formic acid, ascorbic acid, sodium citrate ($Na_3C_6H_5O_7$), sodium boro-hydride ($NaBH_4$) and oxalic acid (El-Nour *et al.,* 2010). The medium of synthesis is binary compound like water or organic solvents (Elemike *et al.,* 2020). There are several chemical methods like polyol method, solvo-thermal reduction, electrochemical techniques, pyrolysis and photochemical reaction (Satyanarayana *et al.,* 2018). The benefits of chemical synthesized nanoparticles are that it permits the production of particles with fixed sizes, dimensions, composition, and structures that might be extensively utilized in many research areas like in catalysis, information storage, drug delivery, imaging, and sensing. Likewise, the operating principles of chemically synthesized nanoparticles can be simply predicted (Deepak *et al.,* 2019).

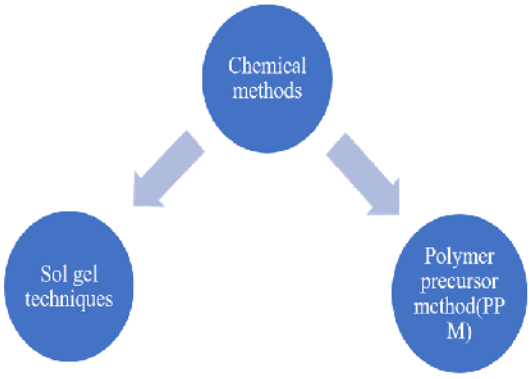

Fig. 1. Chemical Methods.

Sol-gel technique: In sol gel technique, solution is transferred from liquor "sol" to a solidified "gel", to make the colloidal suspension a series of hydrolysis is performed, it makes use of metal oxide synthesis from the chemical solution of polymers. The precursor solution (resistant solution) is used for obtaining powder (fine particles) from it or can be placed into a container or film cast to give it a proper shape. Sol gel silica is porous form of silicon dioxide (SiO_2) which is used for encapsulation matrix to biomolecule species and quantum dot (Sajjadi, 2005).

Advantages:

1. It can make a thin coating to ensure good adhesion between substrate and the top layer
2. It has the capacity of sintering at low temperatures, from 200-600°.
3. It is simple, economical, easy and efficient method to obtain high quality coverage
4. It forms pure products, since the metallic-organic precursor (solution) is mixed in a specific solvent like water and then hydrolysed in soil and thus the composition of gel can be highly controlled

Polymer precursor method (PPM): Pechini method: This method was proposed in 1967 as a way for depositing titanium and niobium. This method is relying on mixing of positive charged ions (small molecules that gained a positive charge), in a solution of polymeric gel and expulsion of matrix (mold) of an oxide with higher uniformity. During this fusion process alkoxides and metal ions are placed in solution of ethylene glycol ($C_2H_6O_2$) and citric acid solution ($C_6H_8O_7$). The resultant citric acid complex results in better distribution of individual ions and also the

separation at later stages can be stop at final condensation production.

Advantages:

1. Versatility
2. Positive charge ions are completely independent of process conditions
3. The process can take place without sintering because of low temperature of the precursor (Modan & Plaiasu, 2020)

Green approach. Green Synthesis of nanoparticles involves the usage of plant extracts (substance that is removed from the tissue of a plant) and micro-organisms or microbes like fungi (eukaryotes) and bacteria (prokaryotic).

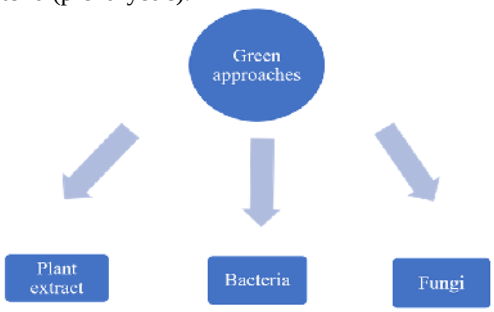

Fig. 2. Green Methods.

Green synthesis of nanoparticles involves the usage of plant extracts and other microorganisms such as bacteria and fungi. Phyto-nanotechnology has proved to be the latest technology which involves environmentally friendly, easy and low-cost synthesis of nanoparticles. Applications of phyto nanotechnology involve usage of reducing agents which are used for quantifying and checking the compatibility of nanoparticles. Mainly plants are involved in formation of nanoparticles in phyto nanotechnology. Different parts of plant are involved like leaflets, seed, fruit (ovary), root (radicle), stem and lead. The main technique for synthesis of nanoparticle makes use of plant remains. It has been found that vitamin C, proteins, organic acid (acetic acid), and secondary metabolites like polysaccharides, steroids, lipid, phenolic, flavonoids, essential oils, terpenoids, chemical compound and alkaloids are found to be the main cause for synthesis of nanoparticles (Ijaz *et al.*, 2020). Using micro-organisms (living body), plant remains and biomass is considered to be the best technique of chemical method for forming nanoparticles because using biological or green synthesis path is extremely quick, economic, non-polluting, sustainable, recyclable and safe. So, living sources such as plants (multicellular organisms), bacteria (single-celled organism), yeasts (eukaryotic), fungi (eukaryotic) and algae can be utilised for modern and more actual biosynthetic approach (Hedaginal & Taranath, 2017).

Plant extract: For the biosynthesis (green approach) of nanoparticles different varieties of micro-organisms such as fungi (eukaryotic), bacteria (single-celled organism) and yeasts (eukaryotic) are utilized. However, a modern trend started in which plant is utilize for the preparation of nanoparticles as it is pollution free, cheaper, easily available, non-toxic, appropriate for extensive production and it is only one step method for synthesis (Huang *et al.*, 2007). The main method for the nanoparticles synthesis is inter-mediated with the help of plants because of the existence of phytochemicals (chemical produce by plants). Some of the crucial phytochemicals such as, phenolic acid (phenol carboxylic acids), aldehydes, flavonoids, curcumin, terpenoids, carotenoids, carboxylic acids, quinone, flavonoids and isothio-cyanate are liable for spontaneous reduction of charged molecules (Prabhu *et al.*, 2012). A few nanoparticles, synthesised through plant extract are mentioned in Table 1.

Table 1: Nanoparticles synthesised through leaf extract.

Sr. No.	Types of Nanoparticles	Name of the leaf extract	Particle size	Reference
1.	Silver	*Phlomis leaf extract*	27nm	Allafchian *et al.*, (2016)
2.	Zinc	*Limonia acidissima*	12-53nm	Naik *et al.*, (2019)
3.	Gold	*Coleus amboinicus*	4.6-55.1nm	Narayanan *et al.*, (2020)
4.	Iron	*Carica papaya*	33nm	Saha *et al.*, (2020)

Bacteria: Several non-toxic inorganic nanoparticles such as magnesium (Mg), gold (Au), cadmium sulphide, silica nanoparticles, silver (Ag) and iron oxide (Fe_2O_3) are produced by different micro-organisms (living body). The bacterial cell provides support to the silver ions inside the surrounding which is liable for the formation of different nanoparticles (Dharmaraj *et al.*, 2016). Bacteria is having tendency to bring down the charged molecules (ions) and then it is employed for the formation of various nanoparticles. Different metal ions (charged particles) are having different harmful effects on bacteria (prokaryotic microorganism). As a result, to defeat such toxicity bacteria formed a protective system i.e., synthesis of insoluble complex or ion (charged particles) reduction (Hulkoti *et al.*, 2014). A few nanoparticles synthesised using bacteria are tabulated in Table 2.

Fungi: High productivity and high quality of nanoparticles can be produced with the help of fungi because it produces huge number of proteins (macronutrients) (Mohanpuria *et al.*, 2008). Fungi, which are complex eukaryotes cell is known for great nano-factories (machine design to produce products).

Table 2: Nanoparticles synthesised using Bacteria.

Sr. No.	Different Type of nanoparticles	Name of the bacteria	Morphological Structure of nanoparticles	References
1.	Silver	*Lactobacillus casei*	Spherical	Korbekandi *et al.,* (2012)
2.	Gold	*E. coli*	Spherical	Du *et al.,* (2007)
3.	Titanium	*Aspergillus favus*	Spherical	Wadhwani *et al.,* (2016)
4.	Gold	*Bacillus subtilis*	Hexagonal octahedral	Southam & Beveridge. (1994)

The reason is they possess good competence to bind with metal ions (charged particles), fungi can grow easily on SSF i.e., solid substrate fermentation, fungi can be developed superficially on inorganic substrate (carbon monoxide and carbon dioxide) throughout culture and resulting in proper delivery of ions (metal).

The benefits of synthesis of nanoparticles are that enzymes which are free from macromolecules can be easily used for downstream process (Nasreen & Taranath, 2014). A few nanoparticles synthesised by using fungi are tabulated in Table 3.

Table 3: Nanoparticles synthesised using Fungi.

Sr. No.	Types of Nanoparticles	Name of Fungi	Properties	References
1.	Silver	*Trichoderma reesei*	-5-50nm -Antimicrobial -Synergic effect on antibacterial activities	Vahabi *et al.,* (2011)
2.	Gold	*Cladospodium Cladosporioides*	-100nm -Antimicrobial -Antioxidant	Danagoudar *et al.,* (2017)
3.	Silver	*Aspergillus fumigatus*	-5-25nm -Antimicrobial activities towards *E. coli, K. pneumonia, Bacillus cereus*	Ratnasri *et al.,* (2014)
4.	Barium ferrite	*Acorus calamus*	- ~70nm -Antifungal agent	Thakur *et al.,* (2020)

Chemical methods Vs green method of nanoparticles synthesis

Advantages of green method: 1. It is utilized for massive production of nanoparticles

2. Energy saving: In chemical method, specific conditions are required for experiments such as high pressure and high energy. But in green method it is not necessary and thus it results in energy saving process

3. Safe product

4. Easy to handle

5. Environment friendly

6. It protects the health of humans and communities

7. The risks of contamination are also lower as there is no use of the chemical reagents

Disadvantages of chemical method: The emitted nanoparticles are derived from waste water can be sublimate on surface water sources, and its aggregation treatment can result in buoyancy increment, as once the deposition of nanoparticles get into land, they may pollute the soil and move into ground water sources (Aslani *et al.,* 2014).

Employs hash reducing agents like sodium borohydride, sodium citrate, alkaline solution, organic solvent etc. The chemical reagents pose toxicity issues and it also effects the environment (Goswami *et al.,* 2019).

Effects of Chemical Vs Green synthesised Nanoparticles on seed germination

Effects of Iron Nanoparticles: Iron is one of the minerals which are naturally available in many foods, plants, etc. This mineral is required for very important purposes. During seed germination or seed growth process, iron provides the energy to the seed and it also helps in transferring the water throughout the plant. Iron also helps in chlorophyll synthesis. But sometimes naturally present iron is not sufficient for the growth of seed and for that iron is provided from outside sources. Abusalem *et al.,* (2019) prepared the nanoparticle through Pistachio leaf extract i.e., Fe Nanoparticle. They showed that green synthesised iron nanoparticle works great in enhancing the seed germination and seedling vigour of tomatoes.

Senthil *et al.,* (2012) Green synthesised iron nanoparticle has good antimicrobial properties. They synthesised iron nanoparticle through *Tridax Procumbens.* While on other hand, chemically synthesised iron nanoparticle is not having positive or more effect than green synthesised iron nanoparticles on seed germination. Toufiq Iqbal *et al.,* (2015) did the experiment of developing iron nanoparticle with $FeCl_3.H_2O$ through aquostic method and their effects on seed germination as well as on growth of BARI Gom25.

They found that increased level of synthesised iron nanoparticle can negatively affect the seed germination and seed growth but if used iron nanoparticle is at optimum level, leads to increase in seed germination process.

Effects of Zinc Nanoparticles: Zinc NPs have both positive and negative effects on germination of seed which depends mainly on its concentration in media. Zinc NPs in agriculture are mostly considered for its anti-microbial activity (Sabir *et al.,* 2014) enhances zinc inadequacy and encourages seed germination in plant (Dimkpa *et al.,* 2015). Zinc is a micronutrient which plays a vital in metabolic activities of plant, the release of Zn^{2+} from zinc nanoparticles occurs in higher content which in seeds may act as plant food in enhancing seed germination (Raskar and Laware, 2014).

Researches showed that higher concentrations of zinc nanoparticles hinder germination of seed (Ko and Kong, 2014), whereas, low doses of zinc nanoparticles showed remarkable positive effects on seed germination (Prasad *et al.,* 2012). Some reports demonstrated that zinc nanoparticles encourage seed germination and seedling growth (Ko and Kong 2014). Treatments with comparatively low zinc nanoparticles concentrations have reported enhancement in germination rate of onion seeds, studies also show that green synthesis of zinc nanoparticles assembled from various zinc compounds (e.g., zinc nitrate, zinc sulfate, zinc acetate) by utilizing extract from different parts of plant such as stem, flower, leaf, and fruit of several plants (e.g., seaweeds, ornamentals, herbs, and trees) (Bala *et al.,* 2015). The plant extract-synthesized zinc nanoparticles are of abundant applications, found to manifest indistinguishable properties such as chemically manufactured zinc nanoparticles. From the presented studies, chemically synthesized zinc nanoparticles decrease the germination rate of seeds as compared to the control and dose dependent manner in *Triticum aestivum* (Awasthi *et al.,* 2017). Some researchers found that the green-synthesized zinc nanoparticles were free of toxic chemicals that make zinc harmful for biological and medical applications (Bala *et al.,* 2015), which gives green synthesis benefit in seed germination.

Table 4: Plants used in the Green synthesis of Zinc, Copper and Titanium Nanoparticles and their Applications.

Nanoparticles	Target plants	Application	Reference
ZnO	*Prosopis julifloravelutina*	Increases the specific activity of seed germination	Hernandez Viezcas *et al.,* (2011)
	Peanut	Increasing stem and root growth	Prasad *et al.,* (2012)
	Oryza sativa L.	Significantly increased in seed priming	Hu *et al.,* (2015)
	Groundnut	Enhanced germination, Catalase enzyme activity	Shyla and Natarajan, (2014)
	Green-gram (*Vigna radiata*)	Early seedling growth and improved seed quality	Shyla and Natarajan (2014)
Copper-sulfate pentahydrate	*Magnolia kobus* leaf extract	Anti-bacterial activity	Lee *et al.,* (2013)
Copper sulfate	*Vitis vinifera* leaf extract	Anti-bacterial activity	Mahavinod Angrasan and Subbaiya (2014)
	Cappariszeylanica leaf extract		Saranyaadevi *et al.,* (2014)
	PhyllanthusEmbilica (Gooseberry) leaf extract		Caroling *et al.,* (2015)
	Nerium oleander leaf extract		Gopinath *et al.,* (2015)
Copper nitrate	*G. superba* leaf extract	Anti-bacterial activity	Naika *et al.,* (2014)
	Tea (*Camellia sinensis*) Andcoffee (*Coffea arabiga*) leaf extract		Sutradhar *et al.,* (2015)
	Tridax procumbens leaf extract		Gopalakrishnan *et al.,* (2014)
Titanium Dioxide hydrate	*Solanum trilobatum* leaf extract	Anti-parasitic activity	Rajakumar *et al.,* (2014)
	Calotropis gigantea flower extract		Marimuthu *et al.,* (2014)
	Catharanthus roseus leaf extract		Velayutham *et al.,* (2012)
	Morinda citrifolia root extract		Suman *et al.,* (2015)
	Psidium guajava leaf extract	Anti-bacterial activity	Santhoshkumar *et al.,* (2014)

Effects of Copper Nanoparticles: Copper is a very crucial micro-nutrient which acts as basic element in proteins and cell wall metabolism, photosynthetic electron transport and hormone signalling (Marschner, 2011). However, when Cu lacks or is in excess, it could cause disorganization and negative impact on seed germination (Yruela, 2009). As anti-bacterial nanoparticle, copper has the benefits of increased abundance present in the soil which is helps in the enhancement of germination rate of seed (Brumbaugh *et al.,* 2014). Green synthesis of copper nanoparticles lessens or eliminates generation of hazardous substances that negatively effects germination of seed. Plant extracts possess numerous low molecular weight metabolites such as amino acid, reducing sugars act as reducing or capping agents during copper nanoparticles chemical synthesis. Also, the plant extract synthesized by chemically synthesized copper nanoparticles mainly have anti-bacterial, photo-catalyst, and anti-oxidant property.

Da Costa and Sharma (2016) observed the exposure of *O. sativa, var. jyoti* to copper nanoparticles decreases the germination rate of seed. A study performed in *Phaseolus radiatus* L. and *T. aestivum* L. discloses that *P. radiatus* L. being more sensitive; copper nanoparticles could cross the cell membrane, clumps in root cell vacuoles of both of the plant (Lee *et al.,* 2008). Although the procedure through which copper nanoparticles enters the plant vascular system, these nanoparticles are absorbed by plants improving seed germination by regulating several enzymatic activities. Copper nanoparticles in hydrogels affected the growth of *S. lycopersicum L*. and *C. annuum L.* plant seed germination (Pinedo Guerrero *et al.,* 2017). Similarly, copper nanoparticles introduced in solution culture, improved the seed germination of *Z. mays*. The copper nanoparticles that enter the plant cells enhance growth and seed germination by activation of enzymes by pentose phosphate pathway.

Effects of Titanium Nanoparticles: Titanium NPs are the most common NPs; the high prevalence of titanium NPs is because of the versatile nature creates the stability of the chemical properties. In addition, almost all reported to have anti-parasitic properties. (Lazareva and Keller, 2014) titanium is probed as significant element for seed germination, as it is qualified for enhancing crop performance and nutrient uptake at low levels. Green synthesized titanium NPs enhances the germination of tomato; radish and onion as green synthesis of titanium oxide nanoparticles have more advantages than with the chemical method. Chemically synthesized titanium nanoparticles are expensive and toxic for seed germination also these nanoparticles are less effective in anti-microbial and anti-parasitic property. On the other hand, green synthesized titanium nanoparticle is low cost and not at all toxic for seed germination. Green-synthesized titanium nanoparticles are highly effective in anti-microbial and anti-parasitic property which helps in the enhancement of seed germination.

Effects of Silver Nanoparticles: Silver possesses both the negative as well as positive qualities towards the seed germination or seed growth. Silver is not naturally present in soil in huge amount, as high amount of silver can be toxic for seed but on the other hand, favourable amount of Ag can become the reason of killing the plant fungus and promoting the seed to grow. Providing of external AgNP can lead to decrease in seed growth as per the results of experiment done by Budhani *et al.,* (2019). Garibo *et al.,* (2020), produced the silver nanoparticle through green synthesis of *Lysiloma acapulcensis*, which exhibits the better antimicrobial qualities as compared to chemically synthesised silver nanoparticle. Antimicrobial activity or quality shown by a plant means it can prevent itself from pathogen which means helping directly to the growth of seed without any infection and external interruptions. Even nowadays, Silver nanoparticles are used for the seed germination enhancement. Silver nanoparticles shows no harmful effect to seed germination and used as steriliser for surface. Depending upon a crop or plant, it may show neutral effect too sometimes. Under the study of silver Nanoparticles, done by Yaku *et al.,* (2019), it is written that in the process of conventional physical and chemical methods perform for synthesising silver nanoparticles, chemical stabilizers and different chemicals are used, which may be toxic for seed germination.

Chemically synthesised silver nanoparticles are expensive to produce, they may show toxicity for seed and they are less effective in showing antimicrobial property of silver. On the other hand, Green synthesised silver nanoparticle with the help of fungi is a good or better alternate for the chemically synthesised or naturally present silver, as it is cost effective, less toxic/not toxic and effective than others (Noshad *et al.,* 2019). An experiment shows that Green synthesised silver nanoparticle possesses beneficial qualities towards seed germination or seed growth such as, it has antibacterial properties for long period of time and it leads to healthy photosynthesis in plants. But, by comparing chemically synthesised silver nanoparticles, they found that green synthesised silver nanoparticles show lesser or low toxic effects on plants/seeds growth (Zhang *et al.,* 2021).

Plants used in the Green synthesis of Zinc, Copper and Titanium Nanoparticles and their applicationsare tabulated in Table 4.

Biomedical applications of the green synthesized nanoparticles

The green synthesized nanoparticles are reliable, good and sustainable method. Green synthesized nanoparticles exhibit different type properties and provide various advantages in different fields. Nowadays, with the speedy development in life various deadly causing diseases are rising. The recent treatment of diseases like diabetes and AIDS is having side-effect on the various parts of body. So, the field of the nanotechnology seems as possible alternate. By using the nanomaterials of different structures, various diseases can be diagnosis with fewer side effects. The green synthesized nanoparticles have several applications in biomedical fields (Ramos *et al.,* 2017).

Delivery of drugs: The nanoparticles synthesized by green route is used for synthesizing medicines because

this method does not use any harmful or toxic chemicals. The main target of the drugs delivery is to improve the treatment with targeted delivery and the side effects should be less. The particles having broad surface area and tiny size shows good activity as compared to large sized of particles (Rizvi & Saleh, 2018). Various designed nanomaterials and nanoscale molecules like liposomes are utilized. The main advantages of nanoparticles are that it can be used as drug carriers because it is having good capacity, viability and stability. By employing nanotechnology to drug delivery, it helps to maintain the drugs for longer period of time in the body for the better treatment. To reduce the aggregation (mass) of drugs, it provides a specific target site. It is used to enhance the potential of delivery drugs that are less soluble in water. One of the most important discoveries in drug delivery is enhanced permeability and retention effect (EPR) (Forokhzad & Langer, 2009).

Diagnosis of diseases: Nanotechnology has various applications in the field of the biomedical sciences. It is used in various devices for protein, drugs, detecting the precancerous cell, diagnosis of cancer, tissue engineering (creation of artificial tissue or organs in the body). Nowadays people are having great expectation from the field of nanomedicine. They are expecting to provide better solution for many diseases. For the diagnosis of cancer, nanoshells can be effectively used. They are circular in shape. The antibodies bind with the polyethylene glycol ($C_{2n}H_{4n+2}O_{n+1}$) and forms a complex then this complex is attached with the surface of the nanoshells nanoparticles and thus target the cancerous cells (Jaishree & Gupta, 2012).

Photothermal therapy: To improve the photothermal therapy scientist uses nanostructures such as graphene oxide and carbon nanotubes. In order to diagnose the cancer, various therapies like chemotherapy and radiotherapy is given to the patients. These therapies have different side effects on the body and thus to overcome this photothermal therapy is introduced with less side effects. Through optical fibres, tumor can be removed from the body. This results in two conditions that is complete ablation of the target tissue and other one is partial ablation of the target tissue. By utilizing the photothermal absorber (carbon-based material), the untreatable tumors can easily be treated with minimum side effects. In case of advanced cancer, it is handling through the usage of partially ablated tumors (Doughty *et al.*, 2019).

Biosensors: Nanomaterials-based biosensors are used for the detection of proteins (amino acids), glucose ($C_6H_{12}O_6$) deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) (Kusakari *et al.*, 2008). For the detection of glucose, various nanoscale materials like magnetic nanoparticles (nickel, cobalt, iron), quantum dots (QDs), platinum nanoparticles (PtNPs) is utilized (Yu *et al.*, 2008).

Table 5: Shape, Structures and Characteristics of various nanoparticles.

Names of the nanoparticles	Structures	Shapes	Characteristics	References
Platinum nanoparticles (PtNPs)	Crystal structure (singly)	Truncated octahedron, rectangular bar	Molar mass is 106.42g/mol Acts as a catalysts Used in fuel cells to improve the quality, shelf life and to make optimum size	Siddiqi & Husen (2016) & Ruffino & Grimaldi (2016)
Silver nanoparticles (AgNPs)	Twinned structure(single)	Bipyramidal	Thermal stable High electrical conductivity Utilize in biosensors Good bactericidal property	Zhang *et al.*, (2016) & Ruffino & Grimaldi (2016)
Gold nanoparticles (AuNPs)	Multiply twinned structure	Pentagonal rod shaped (five-fold twinned)	Stability is high Less toxic Good in biocompatibility Huge area in surface to volume ratio	Yeh *et al.*, (2014)
Palladium nanoparticles (PdNPs)	Multiply twinned structure	Triangular	Good sensor property Shows good Antibacterial activity	Siddiqi & Husen (2016)

Platinum nanoparticles deposits on the surface of multi-walled carbon nanotubes and can be achieved by the mixture of chitosan-SiO_2 and thus the glucose ($C_6H_{12}O_6$) levels of serum sample can be easily detected (Zou *et al.*, 2008).

Dentistry: Nanotechnology plays an important role in our day-to-day life. It is used in the field of the

dentistry, which is known as nano-dentistry. Several types of nanostructures and nanoparticles are utilized for the protection of the teeth. Hydroxyapatite (HAp) is utilized for the improving the implants and for repairing the damaged bone. Hydroxyapatite (HAp) is made up of collagen and it is a natural nanostructured. In the recent time, ceramics is utilized in dentistry. Researchers alter the ceramics by natural means. It is utilized in dentistry to improve biostability and to increase the strength (Priyadarsini *et al.*, 2017).

CONCLUSION

Nanoparticles are those particles which can enhance the properties of plants, seed growth or seed germination. Nanoparticles synthesised through green nanoparticles are less costly. While on the other hand, chemical methods such as sol-gel technique, polymer precursor method, etc, are expensive, which is the first reason why, green synthesised nanoparticles are more preferable over chemically synthesised nanoparticles. Chemically synthesised nanoparticles may be effective or helpful in seed germination but according to our study of different articles shows that, they can be toxic for the seed growth. Green synthesised nanoparticles are better way to enhance the seed germination without or with less toxic effects; they are eco-friendly, cost effective and they possess antimicrobial properties with amazing effects. As mentioned above chemically synthesised nanoparticle's effects are also depends upon the types of soil as well as on the type of crops. Different studies proved that green synthesised nanoparticles can be less effective but they are sustainable or eco-friendly. According to the data collected which are mentioned above, risks in using chemically synthesised nanoparticles are more than green synthesised nanoparticles and they show more phytotoxicity effects towards the seed germination/seed growth. Eventually, collected data disclose that in future green synthesised nanoparticle's benefits will take over on the use of chemically synthesised nanoparticles, because of more advantages of green synthesised nanoparticles.

FUTURE SCOPE OF STUDY

Till date, there have been many researches about the effects of different nanoparticles on plant growth such as; seed germination, root length, shoot length and many more. Many studies have shown that: there are positive effects of nanoparticles on plant growth as well as in the field of agriculture. Studies have also reported that there are harmful effects of nanoparticles on seed germination depending upon whether the nanoparticle is synthesized by green method or chemical method. Green synthesized nanoparticles mostly show positive effect on seed germination and in the field of agriculture, whereas chemically synthesized nanoparticle show negative effect on plant growth and in the field of agriculture. Effect of different nanoparticles on plant growth also varies and depends upon the mode of application whether it is green synthesized or chemically synthesized, size and concentrations of the solution used. Also, more studies are needed, to explore the various effects of metal and metal oxide nanoparticles to enhance the production and quality of crops of agricultural importance. In addition, examination about different concentrations of growth media and the interaction of nanoparticles with minerals to understand its effects should also be performed. Such studies may help to better understand the effect of nanoparticle at deeper level and help in the enhancement in the quality of the plants; yet research focusing on the realization of the beneficial effects of NPs on plant remains incomplete.

Conflicts of Interest. The authors declare no conflicts of interest

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REFERENCES

Abdel-Azeem, E. A., and Elsayed, B. A. (2013). Phytotoxicity of silver nanoparticles on *Vicia faba* seedlings. *New York Science Journal, 6*: 148-156.

Abusalem, M., Awwad, A., Ayad, J., and Rayyan, A. A. (2019). Green Synthesis of α-Fe2 Nanoparticles Using Pistachio Leaf Extract Influenced Seed Germination and Seedling Growth of Tomatoes. *Jordan Journal of Earth and Environmental Sciences, 10*: 161-166.

Adhikari, T., Kundu, S., Biswas, A. K., Tarafdar, J. C., and Rao, A. S. (2012). Effect of copper oxide nano particle on seed germination of selected crops. *Journal of Agricultural Science and Technology, 2*: 815.

Alam, M.J., Sultana, F., and Toufiq Iqbal, M.T. (2015). Potential of Iron Nanoparticles to Increase Germination and Growth of Wheat Seedling. *Journal of Nanoscience with Advanced Technology, 1*:14-20.

Alexis, F., Pridgen, E., Molnar, L. K., and Farokhzad, O. C. (2008). Factors affecting the clearance and bio-distribution of polymeric nanoparticles. *Molecular Pharmaceutics, 5*: 505-515.

Alidoust, D., and Isoda, A. (2013). Effect of γFe_2O_3 nanoparticles on photosynthetic characteristic of soybean (*Glycine max* (L.) Merr.): foliar spray versus soil amendment. *Acta Physiologiae Plantarum, 35*: 3365–3375.

Allafchian, A. R., Zare, S. Z. M., Jalali, S. A. H., Hashemi, S. S., and Vahabi, M. R. (2016). Green synthesis of silver nanoparticles using phlomis leaf extract and investigation of their antibacterial activity. *Journal of Nanostructure in Chemistry,6*: 129-135.

Almutairi, Z. M., and Alharbi, A. (2015). Effect of Silver Nanoparticles on Seed Germination of Crop Plants. *International Journal of Advance Agricultural Research, 4*: 283-288.

Aslani, F., Bagheri, S., Julkapali, N. M., Juraimi A. S., Hashemi, F. S., and Baghdadi, A. (2014). Effects of engineered nanomaterial on plant growth: An overview.*Science World Journal*, 2014: 1-28. Article ID 641759.

Awasthi, A., Bansal, S., Jangir, L. K., Awasthi, G., Awasthi, K. K., and Awasthi, K. (2017). Effect of ZnO nanoparticles on germination of *Triticum aestivum* seeds. *Macromolecular Symposia, 376*: 1700043.

Bala, N., Saha, S., Chakraborty, M., Maiti, M., Das, S., Basu, R., and Nandy, P. (2015). Green synthesis of zinc oxide nanoparticle using Hibiscus subdariffa leaf extract: effect of temperature on synthesis, anti-

bacterial activity and anti-diabetic activity.*RSC Advances, 5*: 4993–5003.

Behboudi, F., Sarvestani, T. Z., Kassaee, M. Z., Sanavi, M., Mohamad, S. A., and Sorooshzadeh, A. (2017). Phytotoxicity of chitosan and SiO_2 nanoparticles to seed germination of wheat (*Triticum aestivum L.*) and barley (*Hordeum vulgare L.*) plants.*Notulae Scientia Biologicae*,*9*: 242-249.

Bhuiyan, S. H., Miah, M. Y., Paul, S. C., Aka, T. D., Saha, O., Rahaman, M. M., Sharif, J. I., Habiba, O., and Ashaduzzaman, M. (2020). Green synthesis of iron oxide nanoparticle using *Carica papaya* leaf extract: application for photo-catalytic degradation of remazol yellow RR dye and antibacterial activity, *Heliyon, 6*: 1-13.

Brumbaugh, A. D., Cohen, K. A., and Angelo, S. K. S. (2014). Ultra small copper nanoparticles synthesized with a plant tea reducing agent. *ACS Sustainable Chemistry & Engineering*,*2*: 1933-1939.

Budhani, S., Egboluche, N.P., Arslan, Z., Yu, H., and Deng, H. (2019). Phytotoxic effect of silver nanoparticles on seed germination and growth of terrestrial plants. *Journal of Environmental Science and Health Part C Environmental Carcinogenesis & Ecotoxicology, 37*: 330–355.

Buzea, C., Pacheco, I. I., and Robbie, K. (2007). Nanomaterials and nanoparticles: Sources and toxicity. *Biointerphases*, 2:MR17-MR71.

Caroling, G., Vinodhini, E., Ranjitham, A. M., and Shanthi, P. (2015). Biosynthesis of copper nanoparticles using aqueous *Phyllanthus embilica* (Gooseberry) extract-characterisation and study of antimicrobial effects. *International Journal of Nanomaterials and Chemistry, 1*: 53–63.

Da Costa, M. V. J., and Sharma, P. K. (2016). Effect of copper oxide nanoparticles on growth, morphology, photosynthesis, and antioxidant response in *Oryza sativa*. *Photosynthetica, 54*: 110–119.

Daniel, K.S.C.G., Vinothini, G., Subramanian, N., Nehru, K., and Shivakumar, M. (2013). Biosynthesis of Cu, ZVI, and Ag nanoparticles using *Dodonaea viscosa* extract for antibacterial activity against human pathogens. *Journal of Nanoparticle Research, 15*: 1-10.

Deepak, P., Amutha, V., Kamaraj, C., Balasubramani, G., Aiswarya, D., and Pachiappan, P. (2019). Green Synthesis, Characterization and Applications of Nanoparticles: Chemical and green synthesis of nanoparticles and their efficacy on cancer cells, *Micro and Nano Engineering*. 369-387.

Dehkourdi, E. H., and Mosavi, M. (2013). Effect of anatase nanoparticles (TiO_2) on parsley seed germination (*Petroselinum crispum*) in vitro. *Biological Trace Element Research, 155*: 283–286.

Dharmaraj, S., Ramya, R. S., Akila, M., Ramanan, J., and Mani, J. E. (2016). Biosynthesis of Silver Nanoparticles Using Extracellular Filtrate of Marine Bacteria and its Antimicrobial Activity. *International Journal of Current Research and Academic Review, 3*: 81-95.

Dimkpa, C. O., McLean, J. E., Britt, D.W., and Anderson, A. J. (2014). Nano-CuO and interaction with Nano-ZnO or soil bacterium provide evidence for the interference of nanoparticles in metal nutrition of plants. *Ecotoxicology, 24*: 119-29.

Elemike, E. E., Ibe, K. A., Mbonu, J. I., and Onwudiwe, D. C. (2020). Phytonanotechnology challenges and prospects. *Micro and Nanotechnologies*, 71-9.

El-Nour, K. M., Eftaiha, A., Al-Warthan, A., and Ammar, R. A. (2010). Synthesis and applications of silver nanoparticles.*Arabian Journal of Chemistry, 3*: 135-140.

Garibo, D., Borbón-Nuñez, H. A., and de León, J. N. D. (2020). Green synthesis of silver nanoparticles using *Lysiloma acapulcensis* exhibit high-antimicrobial activity. *Scientific Reports, 10*: 12805.

Gentile A., Ruffino F., and Grimaldi M. G. (2016). Complex-Morphology Metal-Based Nanostructures: Fabrication, Characterization, and Applications. *Nanomaterials, 6*: 110.

Gopalakrishnan, K., Ramesh, C., Ragunathan, V., and Thamilselvan, M. (2012). Antibacterial activity of Cu_2O nanoparticles on E. coli synthesized from *Tridax procumbens* leaf extract and surface coating with poly-aniline. *Digest Journal of Nanomaterials and Biostructures, 7*: 833–839.

Gopinath, M., Subbaiya, R., Selvam, M. M., and Suresh, D. (2014). Synthesis of copper nanoparticles from *Nerium oleander* leaf aqueous extract and its antibacterial activity.*International Journal* of *Current Microbiology* and *Applied* Sciences, *3*: 814–818.

Goswami, P., Yadav, S., and Mathur, J. (2019). Positive and negative effects of nanoparticles on plants and their applications in agriculture.*Plant Science Today, 6*: 232-242.

Hassellöv., Martin., Readman., James, W., Ranville., James F., and Tiede, K. (2008). Nanoparticle analysis and characterization methodologies in environmental risk assessment of engineered nanoparticles. *Ecotoxicology, 17*: 344–361.

Hedaginal, B. R., and Taranath, T. C. (2017). Characterization and antimicrobial activity of biogenic silver nano-particles using leaf extract of *Thunbergia alata bojer* ex sims. *International Journal of Pharmaceutical Sciences and Research, 8*: 2070-2081.

Hernandez-Viezcas, J.A., Castillo-Michel, H., Servin, A.D., Peralta-Videa, J.R., and Gardea-Torresdey, J.L. (2011). Spectroscopic verification of zinc absorption and distribution in the desert plant Prosopis juliflora-velutina (velvet mesquite) treated with ZnO nanoparticles.*Chemical Engineering Journal, 170*: 346-352.

Hu, J., Salah, S.M., Guan, Y.J., Cao, D.D., Li, J., Aamir, N., Hu, Q.J., Hu, W.M., and Ning, M.Y. (2015). Seed priming with polyethylene glycol regulating the physiological and molecular mechanism in rice (*Oryza sativa* L.) under nano-ZnO stress. *Scientific Reports, 30:* 14278.

Huang, J., Li, Q., Sun, D., Lu, Y., Su, Y., Yang, X., Wang, H., Wang,Y., Shao, W., H, N., Hong, J., andChen, C. (2007). Biosynthesis of silver and gold nanoparticles by novel sundried *Cinnamomum camphora* leaf. *Journal of chemical technology and biotechnology,18*: 1-11.

Hulikere, M., Joshi, C. G., Danagoudar, A., Poyya, J., Kudva, A. K., and Dhananjaya B. L. (2017). Biogenic synthesis of gold nanoparticles by marine entophytic fungus-*Cladosporium cladosporioides* isolated from seaweed and evaluation of their antioxidant and antimicrobial properties. *Process Biochemistry, 63*: 137-144.

Hulkoti, N. I., and Taranath, T. C. (2014). Biosynthesis of nanoparticles using microbes - A review. *Colloids Surface Biointerfaces, 121*: 474-483.

Ijaz, I., Gilani, E., Nazir, A., and Bukhari, A. (2020). Detail review on chemical, physical and green synthesis, classification, characterizations and applications of

nanoparticles. *Green Chemistry Letters and Reviews,13*: 223-245.

Jayandran, M., Haneefa, M. M., and Balasubramanian, V. (2015). Green synthesis of copper nanoparticles using natural reducer and stabilizer and an evaluation of antimicrobial activity. *Journal of Chemical and Pharmaceutical Research, 7*: 251-259.

Ko, K. S. and Kong, I. C. (2014). Toxic effects of nanoparticles on bioluminescence activity, seed germination, and gene mutation. *Applied Microbiology and Biotechnology,98*: 3295–3303.

Korbekandi, H., Iravani, S.,andAbbasi, S. (2012). Optimization of Biological Synthesis of Silver Nanoparticles Using Lactobacillus Casei Subsp. Casei. *Journal of Chemical Technology & Biotechnology, 87*: 932–937.

Lazareva, A., and Keller, A. A. (2014). Estimating potential life cycle releases of engineered nanomaterial from wastewater treatment plants. *ACS Sustainable Chemistry and Engineering, 2*: 1656–1665.

Lee, H., Song, J., and Kim, B. S. (2013). Biological synthesis of copper nanoparticles using Magnolia kobus leaf extract and their antibacterial activity.*Journal of Chemical Technology & Biotechnology,88*: 1971–1977.

Liangwei, Du, L., Jiang, H., Liu, X., and Wang E. (2007). Biosynthesis of Gold Nanoparticles Assisted by Escherichia Coli DH5α and its Application on Direct Electrochemistry of Hemoglobin. *Electrochemistry Communications, 9*: 1165–1170.

Mahavinod Angrasan, J. K. V. and Subbaiya, R. (2014). Biosynthesis of copper nanoparticles by *Vitis vinifera* leaf aqueous extract and its antibacterial activity.*International Journal of Current Microbiology and Applied Sciences, 3*: 768–774.

Marschner, H. (2011). Nanoparticles alter secondary metabolism in plants via ROS burst.*Frontiers in Plant Science, 8*: 832.

Modan, E. M. and Plaiasu, A. G. (2020). Advantages and Disadvantages of Chemical Methods in the Elaboration of Nanomaterials. *The Annals of "Dunarea de Jos" University of Galati. Fascicle IX, Metallurgy and Materials Science, 43*: 53-60.

Mohanpuria, P., Rana, K.N., and Yadav, S. K. (2008). Biosynthesis of nanoparticles: technological concepts and future applications. *Journal of Nanoparticle Research, 10*: 507-517.

Naik, M. M., Naik, H. S. B., Nagaraju, G., Vinuth, M., Naika, H. R., and Vinu, K. (2019). Green synthesis of zinc ferrite nanoparticles in *Limonia acidissima* juice: Characterization and their application as photocatalytic and antibacterial activities. *Microchemical Journal, 146*: 1227-1235.

Naika, H. R., Lingaraju, K., Manjunath, K., Kumar, D., Nagaraju, G., Suresh, D., and Nagabhushana, H. (2015). Green synthesis of CuO nanoparticles using *Gloriosa superba L*. extract and their antibacterial activity. *Journal of Taibah University for Science,9*: 7–12.

Narayanan, K.B., and Sakthivel, N. (2020). Photosynthesis of gold nanoparticles using leaf extract of *Coleus amboinicus* Lour, Materials Characterisation. *Elsevier Science, 61*: 1232-1238.

Noshad, A., Hetherington, C., and Iqbal, M. (2019). Impact of AgNPs on Seed Germination and Seedling Growth: A Focus Study on Its Antibacterial Potential against *Clavibacter michiganensis* subsp. michiganensis Infection in *Solanum lycopersicum*. *Journal of Nanomaterials*, 2019, Article ID 6316094: 1-12 pages.

Pinedo-Guerrero, Z. H., Hernández-Fuentes, A.D., Ortega-Ortiz, H., Benavides-Mendoza, A., Cadenas-Pliego, G., and Juárez-Maldonado, A. (2017). Cu nanoparticles in hydrogels of chitosan–PVA affects the characteristics of post-harvest and bioactive compounds of jalapeño pepper. *Molecules, 22*: 926.

Prabhu, S., and Poulose, E. K. (2012). Silver Nanoparticles: Mechanism of Antimicrobial Action, Synthesis, Medical Applications and Toxicity Affects. *International Nano Letters, 2*: 1-10.

Prasad, R., Bagde, U., and Varma, A. (2012). An overview of intellectual property rights in relation to agricultural biotechnology. *African journal of biotechnology, 11*: 13746-13752.

Rajakumar, G., Rahuman, A. A., Jayaseelan, C., Santhoshkumar, T., Marimuthu, S., Kamaraj, C., and Arora, P. (2014). *Solanum trilobatum* extract-mediated synthesis of titanium dioxide nanoparticles to control *Pediculus humanus capitis*, *Hyalomma anatolicum anatolicum* and *Anopheles subpictus*. *Parasitology Research, 113*: 469–479.

Rani, P., Kaur, G., and Rao, K.V. Impact of Green Synthesized Metal Oxide Nanoparticles on Seed Germination and Seedling Growth of Vigna radiata (Mung Bean) and Cajanus cajan (Red Gram). Journal of Inorganic and Organometallic Polymers and Materials, *30*: 4053–4062.

Raskar, S. V., and Laware, S. L. (2014). Effect of zinc oxide nanoparticles on cytology and seed germination in onion. *International Journal of Current Microbiology and Applied Sciences,3*: 467–473.

Ratnasri, P.V. and Hemalatha, K. P. J. (2014). Biological synthesis of Silver Nanoparticles from *Aspergillus fumigatus*. *Am. journal Advance Drug Delivery, 16*: 683-698.

Sabir, S., Arshad, M., Chaudhari, and S. K. (2014). Zinc oxide nanoparticles for revolutionizing agriculture: synthesis and applications. *Science World Journal, 2014*:925494.

Sajjadi, S. P. (2005). Sol-gel process and its application in Nanotechnology. *Polymer-Plastics Technology and Engineering, 13*: 38-41.

Santhoshkumar, T., Rahuman, A. A., Jayaseelan, C., Rajakumar, G., Marimuthu, S., Kirthi, A. V., and Kim, S. K. (2014). Green synthesis of titanium dioxide nanoparticles using *Psidium guajava* extract and its antibacterial and antioxidant properties. *Asian Pacific Journal of Tropical Medicine, 7*: 968–976.

Saranyaadevi, K., Subha, V., Ravindran, R. S. E., and Renganathan, S. (2014). Synthesis and characterization of copper nanoparticle using *Capparis zeylanica* leaf extract.*International Journal of ChemTech Research, 6*: 974-4290.

Satyanarayana, T., and Reddy, S. (2018). A Review on Chemical and Physical Synthesis Methods of Nanomaterials. *International Journal for Research in Applied Science and Engineering Technology, 6*: 2885-2889.

Senthil, M., and Ramesh, C. (2012). Biogenic synthesis of Fe_3O_4 nanoparticles using *Tridax procumbens* leaf extract and its antibacterial activity on *Pseudomonas aeruginosa*. *Digest Journal of Nanomaterials and Biostructures, 7*: 1655–1660.

Shinde, S., Paralikar, P., Ingle, A.P., and Rai, M. (2020). Promotion of seed germination and seedling growth of Zea mays by magnesium hydroxide nanoparticles synthesized by the filtrate from *Aspergillus niger*. *Arabian Journal of Chemistry,13*: 3172-3182.

Shyla, K. K., and Natarajan, N. (2016). Synthesis of inorganic nanoparticles for the enhancement of seed

quality in groundnut. *Advance Research Journal of Crop Improvement, 7*: 32-39.

Siddiqi K. S., and Husen A. (2016). Green Synthesis, Characterization and Uses of Palladium/ Platinum Nanoparticles. *Nanoscale research letter*, *11*:482.

Southam, G., and Beveridge, T. J. (1994). The in Vitro Formation of Placer Gold by Bacteria. *Geochimica et Cosmochimica Acta, 58*: 4527- 4530.

Suman, T. Y., Ravindranath, R. R. S., Elumalai, D., Kaleena, P. K., Ramkumar, R., Perumal, P., and Chitrarasu, P. S. (2015). Larvicidal activity of titanium dioxide nanoparticles synthesized using *Morinda citrifolia* root extract against *Anopheles stephensi, Aedes aegypti* and *Culex quinquefasciatus* and its other. *Asian Pacific Journal of Tropical Disease, 5*: 224-230.

Sutradhar, P., Saha, M., and Maiti, D. (2014). Microwave synthesis of copper oxide nanoparticles using tea leaf and coffee powder extracts and its antibacterial activity.*Journal of Nanostructure in Chemistry, 4*: 86.

Thakur, A., Sharma, N., Bhatti, M., Sharma, M., Trukhanov, A. V., Trukhanov, S. V., Panina, L. V., Astapovich, K. A., and Thakur, P. (2020). Synthesis of barium ferrite nanoparticles using rhizome extract of *Acorus Calamus*: Characterization and its efficacy against different plant phyto-pathogenic fungi. *Nano-Struct. Nano-Objects, 24*: 100599.

Tile, V.G., Suraj, H.S., Uday, B.M., and Sahana, S.G., (2016). Recent Trends in Nanotechnology and its Future Scope -A Review. *International Journal on Emerging Technologies, 7*: 377-385.

Vahabi, K., Mansoori, G. A., and Dorcheh, S. K. (2020). Biosynthesis of Silver Nanoparticles by Fungus *Trichoderma Reesei* (A Route for Large-Scale Production of AgNPs) *Insciences Journal, 1*: 65-79.

Velayutham, K., Rahuman, A. A., Rajakumar, G., Santhoshkumar, T., Marimuthu, S., Jayaseelan, C., and Elango, G. (2012). Evaluation of *Catharanthus roseus* leaf extract-mediated biosynthesis of titanium dioxide nanoparticles against *Hippobosca maculata* and *Bovicola ovis*. *Parasitology Research, 111*: 2329–2337.

Wadhwani, S. A., Shedbalkar. U. U., Singh. R., and Chopade. B. (2016). Biogenic Selenium Nanoparticles:Current Status and Future Prospects. *Applied Microbiology and Biotechnology, 100*: 2555–2566.

Yaku, G., Rekha, C., and Rao, P., (2019). Microwave-Assisted Green Synthesis of Silver Nano-particles using Pithecellobium dulce (pulichinthakaya): Characterization and Detection of Hg+2 And Fe+3 metal Ions. *International Journal on Emerging Technologies, 10*: 325-334.

Yeh Y., Creran B., and Rotello V.M. (2014). Gold Nanoparticles: Preparation, Properties and Applications in Bionanotechnology. *Nanoscale, 4*: 1871-1880

Yruela, I. (2009). Copper in plants: acquisition, transport and interactions. *Functional Plant Biology,36*: 409–430.

Zhang X.F., Liu Z.G., Shen W., and Gurunathan S. (2016). Silver nanoparticles: synthesis, characterization, properties, applications and therapeutic approaches. *International journal of molecular science, 17*: 1534.

Zhang, H., Chen, S., Jia, X., Huang, Y., Ji, R., and Zhao, L. (2021). Comparation of the phytotoxicity between chemically and green synthesized silver nanoparticles. *Science of the Total Environment, 752*.

Zhang, H., Yue, M., and Zheng, X. (2017). Physiological effects of single-and multi-walled carbon nanotubes on rice seedlings. *IEEE Transaction Nanobioscience, 16*: 563–570.

Zhang, J., and Saltzman, M., (2013). Engineering biodegradable nanoparticles for drug and gene delivery. *Chemical engineering Progress, 109*: 25-30.

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