International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(3): 1758-1760

Received: 04-03-2018
Accepted: 06-04-2018

PN Patle
Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

PR Kadu
Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

AL Pharande
Department of Soil Science and Agricultural Chemistry, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Correspondence
PN Patle
Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Nanotechnology: An emerging trend in soil science and plant nutrition research the review with an overarching approach

PN Patle, PR Kadu, AL Pharande

Abstract
Agriculture is the backbone of most developing countries, with more than 60% of the Population reliant on it for their livelihood. Agricultural scientists are facing a wide spectrum of challenges such as stagnation in crop yields, low nutrient use efficiency, declining soil organic matter, multi-nutrient deficiencies, climate change, shrinking arable land and water availability and shortage of labor besides exodus of people from farming. To address these problems, there is a need to explore and emerge one of the frontier technologies such as 'Nanotechnology' to precisely detect and deliver the correct quantity of nutrients and pesticides that promote productivity while ensuring environmental safety and higher use efficiency. Nanotechnology deals with the matter at nanoscale (1-100 nm) dimensions. These materials when reduced to the nanoscale show some properties which are different from what they exhibit on a macro scale, enabling unique applications. Nanotechnology has great potential, as it can enhance the quality of life through its applications in various fields like agriculture and the food system. This technology can boost agricultural production, and its applications include: 1) nano formulations of agrochemicals for applying pesticides and fertilizers for crop improvement; 2) the application of Nano sensors/Nano biosensors in crop protection for the identification of diseases and residues of agrochemicals; 3) Nano devices for the genetic manipulation of plants; 4) plant disease diagnostics; 5) animal health, animal breeding, poultry production; and 6) postharvest management. The present paper reviews the emerging trend and some of the potential applications of nanotechnology in the field of agriculture with precise exceptional pivot towards soil science research interventions.

Keywords: Nanotechnology, nanoparticles, agriculture, emerging technology, applications, soils

1. Introduction
Now a day's, the major challenges faced by world agriculture include changing climate, urbanization, sustainable use of natural resources and environmental issues like runoff and accumulation of pesticides and fertilizers (Chen H, 2011) [5]. To overcome these problems, many technologies have been developed that have the potential to increase farm productivity and also reduce the environmental and resource costs related with agricultural production. Nanotechnology is actually the science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers. Nanotechnology, this vast field of the 21st century, is making a very significant impact on the world's economy, industry and people's lives (Mulligan C N, *et al.* 2001) [8]. It deals with the physical, chemical and biological properties of matter considered at nano-scale (1–100 nm) and their implications for the welfare of human beings. The nanotechnology aided applications have the potential to change agricultural production by allowing better management and conservation of inputs of plant and animal production. Nano partial (NPs) are generally define as material that are <100 nm size (0.1µm) in at least one dimension.

The application of nanomaterial's in agriculture aims in particular to reduce applications of plant protection products, minimize nutrient losses in fertilization, and increase yields through optimized nutrient management. Nanotechnology is the ability to look deep into what and how basic element is created and how they can be manipulated to benefit mankind. Nanotechnology has not left agriculture untouched, rather nanotechnology promises to revolutionize the agriculture sector with new tools for molecular treatment of plant to absorb nutrient thus increasing soil fertility and crop production. in this review, nanotechnology in agriculture sector has to be introduce which is likely to bring a sea change in agriculture production and productivity (Adhikari T. *et al.*, 2009). The nanotechnology can be exploited in the

value chain of entire agriculture production system (Subramanian and Tarafdar, 2011) [11].

2. What is Nanotechnology?

Nanotechnology is defined as an understanding and control of matter at dimensions of roughly 1-100 nm, where unique physical properties make novel application possible (EPA, 2007) [7]. The British Standard Institution (BSI, 2005) and American Society for Testing and Materials (ASTM, 2006) defined nanotechnology as "Design, characterization, production and application of structure, devices and system controlling shape, size and composition at the nanoscale ". Nano particles are generally defined as material that are <100 nm (0.1µm) in at least one dimension. This mean that nano material can be three dimensional particles (Spherical, cuboids etc), or two dimensional particles (ultra and film) or one dimension (fine rods). Their chemical (reactivity, solubility etc), mechanical (elasticity, hardness etc), electronic (conductivity, redox behavior) and nuclear (magnetic) properties often change as function of size. Ultimately, nanotechnology could be described as the science of designing and building machines in which every atom and chemical bond is precisely specified. It is not a set of particular techniques, devices, or products, but the set of capabilities that we will have when our technology comes near the limits set by atomic physics (Storrs Hall J, 2006) [12]

3. Nano-Particles and its Unique Features

Because of small size, the physical, chemical, electronic properties of nano-structure changes as function of size and are very different from that of their bulk counterpart. Due to small size of nano-particles, there are more atoms on the surface compared to the interior of particles, which lead to a large surface to volume ratio which in turn lead to higher reactivity of nano-particles. The large surface to volume ratio also results in more interaction between atoms in intermixed material in nanoparticles, which may lead to increase strength, increase heat resistance etc. melting points of nanoparticles decrease for cluster smaller than a few hundred angstroms.

4. Type of Nano materials

4.1 Carbon-based nanomaterial's

These nonmaterials are composed mostly of carbon, most commonly taking the form of a hollow spheres, ellipsoids, or tubes. Spherical and ellipsoidal carbon nonmaterials are referred to as fullerenes, while cylindrical ones are called nanotubes. These particles have many potential applications, including improved films and coatings, stronger and lighter materials, and applications in electronics (Oberdorster *et al.,* 2006) [9].

4.2 Metal-based nanomaterial's

These nanomaterials include quantum dots, Nano gold, and Nano silver and metal oxides, such as titanium dioxide, zinc oxide, magnesium oxide, iron oxide etc. A quantum dot is a closely packed semiconductor crystal comprised of hundreds or thousands of atoms, and whose size is on the order of a few nanometers to a few hundred nanometers. Changing the size of quantum dots changes their optical properties (Dreizin, 2009) [6].

4.3 Dendrimers

These nanomaterials are Nano sized polymers built from branched units. The surface of a dendrimer has numerous chain ends, which can be tailored to perform specific chemical functions. This property could also be useful for catalysis. Also, because three-dimensional dendrimers contain interior cavities into which other molecules could be placed, they may be useful for drug delivery (Astruc *et al.,* 2010) [3].

4.4 Nanocomposites

Combine nanoparticles with other nanoparticles or with larger, bulk-type materials. Nanoparticles, such as Nano sized clays, are already being added to products ranging from auto parts to packaging materials, to enhance mechanical, thermal, barrier, and flame-retardant properties (Ajayan *et al.,* 2003) [2].

5. Method of Nano-Particles Production

Nanoparticles can be produced by variety of method. These include combustion synthesis, plasma synthesis, wet phase processing, chemical precipitation, sol gel processing, mechanical-chemical synthesis, and high energy ball-milling, chemical vapor deposition and laser ablation. This synthesis procedure divided into two main domains including:

5.1 Bottom-up

The processes (such as self-assembly) that create nanoscale materials from atoms and molecules. The approach involves condensation of atoms or molecular entities in a gas phase or in solution allowing for the precursor particles to grow in size the method includes, sol-gel processing, chemical vapor deposition (CVD), plasma or flame spaying synthesis, laser pyrolysis and atomic or molecular condensation. (Petit *et al.,* 1993) [10].

5.2 Top-down

Processes (such as milling) that create nanoscale materials from their macro-scale counterparts. Nanoscale materials that have macro-scale counterparts frequently display different or enhanced properties compared to the macro-scale form (Petit *et al.,* 1993) [10].

6. a) Application of Nanotechnology in General Soil Science and Plant Nutrition

Nanotechnology is multidiscipline science and application of nanotechnology in various fields in soil science research and avenues apart from it can be attributed in kinder branches as these are presented under following section:

1. Physics
2. Chemistry
3. Biology
4. Information technology
5. Mechanical engineering
6. Imaging technology
7. Agriculture etc.

6. b) Application of Nanotechnology concretely in Soil Science and Plant Nutrition

Natural nanoparticles have existed since before life began on earth All life form that have exposed to at least some type of nanoparticles during their evolution, and they have thus developed mechanism to tolerate presence (Buffle, 2006) [4].

The most common natural nanoparticles are soil colloids, which are constituted of silicate clay mineral, iron or aluminum oxide /hydroxide, or humic organic matter, including black carbon. A large number of nanoparticles are present in the soil environment and understanding the behavior of nanoparticles is very important to wide variety of soil processes pertaining to plant nutrition and soil

reclamation there are some important application of nanotechnology in soil science and plant nutrition as given below:

Soil colloid should be viewed as an essential building block of the abiotic medium supporting life in general (Buffle 2006) [4]. During the weathering of silicate oxide and other minerals, a number of NPs such as halloysite and oxide such as magnetite and hematite, are produced in soil but their precise function and effect are still poorly defined and understood. Microorganism can also produce NPs though the generation of metabolic energy by pathways involving inorganic ion that formation of ion that participate in redox reaction. Oxidation of Fe (II) results in the formation iron oxide NP.

There are numerous nano-enhanced products in different countries and nano-based tools and method with immediate application to addressing the issue pertaining to low use efficiency of input like water fertilizers etc. This includes nano-enhanced product such as nano-fertilizer with nano-based smart delivery system (use of halloysite) to provide nutrient to desired site, time and rate to optimize productivity. The nano-fertilizer can be delivered timely to a rhizopheric target or by foliar spray for higher use efficiency. The emerging literature on nano-technology has started to show the importance of nano-particles in increasing bio-availability of nutrient element and transport of pollutant in soil. Fertilizer play pivotal role in the agriculture production up to 35 to 40% of the productivity. To enhance nutrient use efficiency and overcome the chronic problem of eutrophication, Nano fertilizer might be a best alternative. Attempts have been made to synthesize Nano fertilizer in order to regulate the release of nutrients depending on the requirements of the crops, and it is also reported that Nano fertilizer are more efficient than ordinary fertilizer (Liu *et al.*, 2006).

Several synthesized NPKs like amphiphilic polyurethane, zerovalent ion (nZVI) and nano sized zeolites are widely used for reclamation of heavy metals and poly-aromatic hydrocarbons contaminated soil. This show that nano-sized TiO_2 (Titanium Dioxide) can have positive effect on growth of spinach when administrate the seed or sprayed onto the leaves whereas nano TiO_2 was found to show toxic effect in green algae which have a cell wall similar to plant. The most possible interaction of NPs with plant root is adsorption onto root surface, incorporation into the cell wall. A survey by Salamanca–Buentella *et al.* (2005) predicted several nanotechnology applications for agricultural production for developing countries within next 10 years. These included -

(I) Nanoforms zeolites for slow release and efficient dosage of water and fertilizers for

Plants; drugs for livestock; nanocapsules and herbicide delivery.

(ii) Nanosensors for soil quality and for plant health monitoring; nanosensors for pest

detection.

(iii) Nanomagnets for removal of soil contaminants.

(iv) Nanoparticles for new pesticides, insecticides, and insect repellents.

7. Future Prospect

There are some future prospects and researchable issue in agriculture pertinent to nanotechnology are (1) Development of Nano-sensor to monitor soil quality, (2) development of Nano-magnets for soil contaminant retrieval, (3) development of Nano-membrane for water treatment and purification, (4) fertilization and herbicides application through NPs, (5) synthesis of Nano-fertilizer for soil and plant application (6) establishment of baseline information on safety, toxicity and adaption of NPs in soil and adequate life.

8. Conclusions

Nanotechnology is capable of being used in agricultural products that protect plants and Monitor plant growth and detect diseases. Scientists are still seeking new applications of nanotechnology in agriculture and the food industry. The agricultural sector and the food industry will indeed see tremendous changes for the better in the coming years. It can also be concluded after understanding ongoing research worldwide that major scientific research on plant nutrition and fertilizer industry will shift their accent towards nanotechnology, while it will gain prominent place in soil science research methodology.

9. References

1. Adhikari Tapan, Kundu S, Subba Rao. Indian Institute of Soil Science (ICAR) Bhopal -462038 MP, India, 2013.
2. Ajayan PM, Schadler LS, Braun PV. Nanocomposite science and technology, Wiley, 2003.
3. Astruc D, Boisselier E, Ornelas C. Dendrimers designed for functions: from physical, photophysical, and supramolecular properties to applications in sensing, catalysis, molecular electronics, and nanomedicine. Chemical Review. 2010; 110:1857-1959.
4. Buffle J, The key role of environment colloids /nanoparticles for the sustainability of life. Environ. Chem. 2006; 3:155-158.
5. Chen H, Yada R. Trends Food Sci. Technol. 2011: 22: 585.
6. Dreizin EL. Metal-based reactive nonmaterials. Prog. Energy Combust. Sci. 2009; 35:141-167.
7. EPA. Nanotechnology white paper, U.s Environmental Protection Agency Report EPA 100/B-07/001, Washington DC 20460, USA, 2007.
8. Mulligan CN, Yong RN, Gibbs BF. J Hazard. Mater. 2001; 85:111.
9. Oberdorster E, Zhu S, Blickley TM, Green PM, Haasch ML. Ecotoxicology of carbon based engineered nanoparticles: Effects of fullerene (C60) on aquatic organisms. Carbon. 2006; 44:1112-1120.
10. Petit C, Lixon P, Pileni MP. In situ syntheses of silver nanocluster in AOT reverse micelles J Phys. Chem. 1993; 97:12974-12983.
11. Salamanca-Buentello F, Persad DL, Court EB, Martin D K, Daar AS, Singer PA. Nanotechnology and the developing world. PLoS Medicine. 2005 2:383-386.
12. Storrs Hall J. Nanofuture: What's next for Nanotechnology? Amherst, NY, USA: Prometheus Books. 2006.
13. Subramanian KS, Tarafdar JC. Prospects of nanotechnology in Indian farming. Indian Journal of Agricultural Sciences. 2011; 81:887-893.