International Journal of Modern Agriculture, Volume 10, No.2, 2021
ISSN: 2305-7246

Nanotechnology In Sustainable Agriculture: Review And Challenges

Dr. Shakuli Saxen[1]

[1] Department of Agriculture, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India

Email id- [1]shakuli.agriculture@tmu.ac.in

Abstract

In recent years, intensifying conventional agricultural practices act as an immediate method for growing global meals supply, however immoderate use of agrochemicals reason pollutants. Imbalanced nutrient control and decreased soil natural count are the primary factors liable for yield decline. Nanotechnology is an innovative generation and has wide range of capacity environmental and engineering programs like in agricultural systems, biomedicine, water resources, energy conversion and several other areas. Advancement in materials science extended exponentially within the last decade and arriving in our days at a big sort of Nanomaterial, which can deliver new environment technologies, because of their immensely powerful capability. This article reviewed the ability makes use of Nanomaterial in sustainable agriculture with precise reference to soil remediation and environmental cleaning. The nanotechnology industry has the potential, with new Nanotoils to control rapid diagnosis of anilments as well as increase plant-life capacity for taking nutrients, amongst many other things, to improve farming and food companies. Specific programmes such as nanofertilizers as well as nanopesticides to trail goods as well as vitamin increase productivity without decontaminated soils, water and protection against various pests and microbial disease are important to the use of nanotechnology in farming..

Key words: Agriculture, Nanomaterials, Nanotechnology, Sustainable Agriculture, Biomedicine, Growth.

Introduction

Agricultural area is the backbone of Indian rural economic system and performs an enormous function inside the manner of monetary enlargement [1]. Approximately 60% of Indian population and 115 five million human beings depend on agriculture considering independence. In current years, intensifying conventional agricultural practices (like use of chemical fertilizer, pesticides and heavy irrigation) changed into practiced as an immediate method for growing global food deliver, but the excessive use of agrochemicals cause pollutants of biosphere. Imbalanced nutrient control and reduced soil organic matter are the main factors chargeable for yield decline. For enhancing soil organic matter status and growing crop production, addition of crop residue, farmyard manure and inexperienced manure are widely diagnosed agricultural practices. Besides these, there may be a new trade option that is use of Nanomaterials in agricultural field [3]. Use of Nanomaterials in agricultural industry is not only useful in discount of use of chemical fertilizer and pesticide, famine, hunger etc. however also in soil remediation. In the existing article, we speak the usage of Nanotechnology (Nanomaterials) in area of sustainable agriculture with special emphasis on soil remediation and in environmental cleaning.

Agricultural sector is a region that is continuously as crucial and stable as it provides and provides raw materials for the food industry as well as feed industry. The limited supply of cheap resources (land production, soil, water, etc.) as well as the population increase in the global setting mean that the economic, environmental and effective growth of agriculture is further enhanced. This change could be crucial in the last year for many aspects. The economic expansion of agricultural nutrients balances and thus the growth of soil quality is particularly important for the growth countries [2]. Bio-sensor growth is also an outstanding field to use several of the nanotechnology's strengths, and therefore nanotechnology has an important role to play. Because large companies of nanomaterial on one hand, biosensors can increase their responsiveness and performance significantly, and several new sign transduction technologies can be introduced in biosensors. Biosensors are available in their bundles. In conjunction with Nano sensors and various Nano systems, most of which are very important in biochemical analysis are often miniaturised with the use of nanomatherapies to relatively compact / smart equipment. It also aims to detect mycotoxins in several spices but rather their capacity is quite quick. [3] [4].

Nanotechnology is the new developing discipline in the agriculture zone as it's far considered one of the most critical gear in the agricultural programs for plant and crop performance. They have multifunctional role in exclusive fields which includes water treatment, biomedical and drug shipping, metallurgy and substances, strength garage and agriculture and biotechnology (Figure 1). Sometimes Nanomaterials can also use in oil seal applications in rubber industry because it has advanced homes amongst all fillers. Modern agricultural practices have caused soil degradation due to soil erosion, soil acidity, alkalinity, loss of microbial hobby etc. Nanotechnology can function major tool in remediating the negative consequences related to soil health [7]. Nanoparticles in agricultural field keep away from extra use of chemical compounds which include fertilizers and insecticides that have terrible impact on soil consisting of nutrient loss, soil infertility and leaching etc. And it increases produce performance and productivity via water and nutrient satisfactory enhancer.

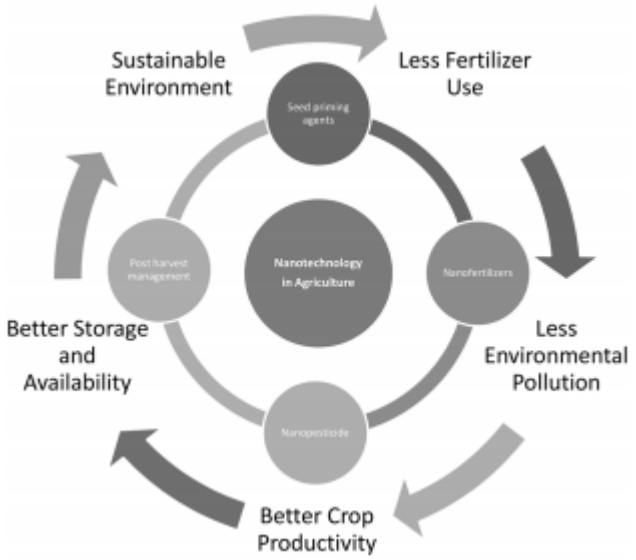

Figure 1: Advantages of Nanotechnology in Agriculture

Nanotechnology has provided new opportunities to advance nutrient use performance, Nano fertilizer replaces the traditional fertilizer practices and enhance the soil characteristics. It is useful in absorption of nutrient to plant roots and microorganism and enhancing crop productivity. Plant growth-selling rhizobacteria (PGPR) additionally acts as fertilizers via conventional technique, they're effective in some cases, at the same time as Nano encapsulation era may be used as a way to defend PGPR and improving their retention time in soil micro vegetation and fauna. Nanomatrials also are useful in immobilization of nutrients and discount of leaching. It controls eutrophication with the aid of decreasing the transfer of nitrogen and different chemical substances to surface and ground water. On the alternative hand, Nanotechnology could helpful in structure and feature of pesticides by improving solubility, enhancing resistance in opposition to photo catalysis and hydrolysis and by means of providing an extra precise and controlled launch towards target pest [5]. Nano-encapsulations for drug shipping also are important practices for control of pest and pathogen and enhance crop productiveness.

Nanotechnology And Agricultural Sustainable Development

Nanotechnology could play an important role in efficiency by managing vitamins and can also be involved in the tracking of first-class water as well as chemicals for sustainable farming enhancement. Nanomaterials really have a variety of resources as well as operations that a trendy assessment of environmental impacts is unthinkable [10]. Nanoparticles can influence the toxicity characteristicsTherefore, nanomaterials with much the same chemical composition having various sizes or forms also may demonstrate about their various toxicity., including chemical composition, floor structure, surface loading, behaviour, scale of particle agglomeration (clushing), variability, etc.

Indeed the significant element of environmental sustainability is increasingly the involvement of the nanotechnology investigations in the agriculture sector. Relevant carbon nanotube, fullerenes, biosensing, regulated supply systems, nanofiltration etc. programmes were identified in the agro - based sectors. Each era has proven to become the leader in agricultural field controls, pharmaceutical processes in plants and soil fertility control. In regard to meal preparation and distribution packaging systems, Biomass as well as agricultural waste are continually monitored, in addition to hazard assessment. Nanosensors have been used widely in farming lately, due to their strengths and quickness, to monitor pollution in water and soil in the climate. Many Nano-detection produced sensors might be the issues concerned for tracking toxic metals (biosensors, optical sensors and devices).

It does not catalyse the wastes deterioration with dangerous substances in a most efficient way, However, instead it seeks to enhance waste and hazardous chemicals' productivity of microbes. In order to decay or eradicate soil moisture pollution and dangerous materials, bio structuring uses living things. There is also wide-ranging use of specific terms like bioremediation (professional microbes), plant recovery and remediation (fungi and mushrooms). Consequently, toxic chemical substances can be environmentally erased from water and soil effectively by using organisms. [6]. Thus, the farming bioremediation assists in sustainable treatment techniques to solve and improve natural current situation of the soil. This is a thrilling phenomenon in considering more about Nano–Nano interaction to remove the harmful factor of a agricultural soil will make it viable [6].

Micro- and Nano encapsulation:

The encapsulation is defined as a procedure by which a provided item is enclosed through a coating or embedded in a homogenous or diverse matrix, hence tablets with a large lot of excellent households [7]. Reliant upon size and type of tablets different epitome innovation are referenced, while the (large scale) exemplification/covering results drugs in full scale, while the miniature The Nano incarnation would then impart miniature particles and Nano composites. Nanocapsules are vesicular constructions wherein the materials are confined to a hole comprehensive of an inward fluid center encased with the guide of a polymeric film. Miniature as well as NPs are considered as long for both the transit of containers, health coverage and growth in the bioavailability of dinners with additives or nutraceuticals as well as for the supper fortification and trying to mend of some chemicals [8]. Nano-encapsulated are a few drugs that contain peptides and anti-inflammative compounds. In order to provide the target tissues with a range of biologically vivid compounds, the advancement of Nano encapsulated schemes to link aimed cells to Nanomaterials. In addition, the technological advancement will produce new tablets containing special therapeutic movement for slaughtering tissues. Nanocapsules could be used as nanorobots guided by MRI [9].

Nanotechnologies In Food Industry:

Microbial reconnaissance and determination can be carried out by nano-scale biosensing. In the foodstuffs sector, nanoscience may supply hosts with bioactive substances while increasing the know-how of nanofood. It likewise permits in Nano scale filtration structures for advanced surface modification of dinners. Nano biosensors draw in with dinners, engaging surface and therefore save the glaziers and tones of suppers, attractive Nano composite for label sensors. Nano printed, smart bundling, controlled dispatch Nano-added substances. Nano-coding of plastics and paper materials for confirmation and identification purposes. In food remarkable tests, a couple of significant viewpoints should be covered which incorporates detecting limit of mark and bundle, in situ sensors, food best monitoring(such as taste, shading, pattern, smell,), oversee and nutraceuticals conveyance, movable DNA/protein chips, and so forth More often than not, Nanomaterials delivered by means of bottom−up methods [10].

Nanoemulsions:

Nanoemulsions are synthesized by means of little emulsion Nanoscale beads (water/oil gadget) showing sizes lower than~100 nm Although basically significant contrasts among Nanoemulsions and miniature emulsions couldn't be exists, anyway indeed, the substantial places of Nano emulsions might be quite unique in relation to the ones of small size emulsions(Due to the size of drops, Laplace stress, the proportion of floor are at volume,

and flexible modulus of Nano emulsions are significantly bigger than that of ordinary emulsions. In addition not at all like notable emulsions, limit of Nano emulsions show up optically straightforward that, consequently, in fact have numerous gifts make such us consolidation into drinks. Shockingly, the strategy for Nano emulsion needs exceptionally exorbitant energy, therefore it requires some interesting devices which can create outrageous shear pressure which incorporates, high strain homogenization or ultrasonic generator revealed "low-energy" approach for development of Nano emulsions and thusly, fluid stages (one is a homogeneous fluid comprised of hydrophilic surfactant as well as lipophilic stage and in addition to surely a dissolvable, drug or may be polymer and the inverse is a watery stage [11].

Nanotechnology And Soil Remediation:

Nanotechnology provide new equipment for agriculture and soil remediation. Nanoscale iron debris are very powerful for the transformation and cleansing of a wide form of commonplace soil contaminants, which include chlorinated natural solvents, organochlorine pesticides, and polychlorinated biphenyls (PCBs). Nanoscale based zero-valent iron is most extensively used Nanomaterials that would remediating pollution in soil. Other Nanoparticles that would be utilized in remediation such as Nanoscale zeolites, steel oxides, carbon Nanotubes etc. Nanoparticle filters can be used to do away with natural particles and pesticides from water. Application of Nanoparticles (P, Zn, Mg) as vitamins may additionally trigger enzymes and increase selling materials to launch via roots resulting influence on microbial population within the rhizosphere and Nanosensors that can assist in tracing precise microbial overall performance within the rhizosphere.

Nanotechnology is additionally useful in soil moisture capturing. Hydrogels, polymers, Nano-clay and Nano-zeolites were mentioned to encouraging the water holding capacity of soil, therefore greater retention time and sluggish release of water for the duration of crop season and decrease water deficiency of the crop [12]. Nanotechnology raises hope for brand spanking new innovation within the area of soil control and agricultural software. New studies goal is to make flora use water, fertilizers, and pesticides greater efficiently and reduce pollutants and fee to make agro ecosystems eco-pleasant. Nanotechnology is extensively used in agriculture sector for productiveness enhancement by way of Nano-porous zeolites (for slow release and effective dosage of water and fertilizer) and Nano-drugs (for herbicides creation and pest management). Application of Nanotechnology additionally encourages the high-quality of meals for consumers that are wealthy in micro and macro vitamins. Some Nanotechnology practices are also relevant at industrial level which include Nanosensors and Nanoscale coating that replace the thicker more waste polymer coating and prevent corrosion.

Nano biosensors:

Numerous benefits of real compound places of Nanoscale substances likewise are exploitable in field of biosensors improvement of biosensors said that the responsiveness and in general execution of biosensors can be ventured forward via utilizing Nanomaterials through new sign transduction innovations. The unfathomable progression inside the Nano biosensors are a direct result of the overly innovative interest for quick, touchy and cost successful Nano biosensor frameworks in basic locales of human interest which incorporate wellness care, farming, genome examination, drinks as well as the food, the method businesses, natural checking, guard, and security. At blessing, the Nanotechnology-fundamentally put together biosensors are with respect to the beginning phase of improvement..

The Nanomaterials like steel (silver, cobalt, gold, etc) CNT, had been adequately inspected for their ventures in biosensors which had come to be another interdisciplinary wild among natural area and texture advancement. In this manner a biosensor is a contraption that merges a characteristic affirmation part with physical or substance guidelines. It consolidates a characteristic one with an electronic issue to yield a quantifiable sign part, and the regular affirmation is through the transducer method and the sign planning through mechanized achievement. The better specificity and affectability of biosensor structures over the customary methodology are an aftereffect of the presence of the bio receptor (normal segment) this is mixed in with a fitting transducer which makes a sign after exchange with the target molecule of interest [13].

Nanopesticides:

The utilization of NMs in flora insurance and assembling of suppers is under-investigated zone inside what's to come. It is broadly realized that creepy crawly nuisances are the fundamental ones inside the agrarian fields, subsequently NPs might also furthermore include key situation inside the regulating of bug irritations and host microorganisms. The new improvement of a Nano embodied pesticide recipe has steady delivering properties with more grounded dissolvability, specificity, penetrability and security. These property are predominantly accomplished through either safeguarding the exemplified energetic components from untimely debasement or developing their vermin oversee efficacy for a more extended period. Detailing of Nano epitomized bug sprays achieved diminish the measurement of pesticides and individuals exposure to them that is naturally wonderful for crop assurance So, improvement of non-noxious and promising pesticide conveyance frameworks for expanding worldwide food creation while diminishing the poor ecological impacts to biological system [13].

Nano-Particular Ecotoxic Implications

The progress of nanomaterials has provided environmental conditions to significant levels of generated NP. A numerous studies aimed at assessing the potential harms of nanoparticles commonly used throughout major businesses for monitoring human well though and plant from the imaginable unfriendly implications of a diverse variety of nanostructures. The poisonousness of a metal relies on various variables like solvency, restricting specificity to a natural site, etc. Metal NPs flaunt antibacterial and antifungal games. Metal Nano particles apply cytotoxicity depending on the rate at film floor, obviously, the productivity of Nano harmful impacts of Nano particles are definitely depending on state of focused cell-divider.

Eco toxicological examinations would progressively intrigue on the ecological impact of the substances and intricacy of normal designs. The diverse screening can be essential in selecting the delayed impact of natural NP visibility and in determining appropriate, highly customizable tools. More exams on bioaccumulation and in supper chain as well as connection between NPs and various climatic infections. NPs throughout the tissue frame in the plant, shoo and retain them in different high sections, will increase the chances of cycling only within atmosphere by various trophic levels [14].

Conclusion

Agribusiness that is the best supplier of human's dinners that need to create from temporary final contributions with generally perceived advancements. Hence, it is crucial to require a current mastery in agribusiness. Regardless of being relative advantages in agribusiness measure, actually non-industrial nations are suffering from absence of over the top significance of food items. Regardless of heaps of insights about individual Nanomaterial are accessible, yet harmfulness level of numerous NPs is as yet indefinable, consequently the product of such materials is restricted because of the absence of comprehension of risk evaluations. Advancement of extensive information base and caution contraption, just as overall participation for law and guideline are crucial for abuse of this period. Nanotechnology is incredible assets for soil control and farming assembling and also in remediation of environmental factors. It is additionally alluded to as green Nanotechnology or clean innovation since it can possibly decrease ecological contamination and human wellbeing threat by methods for use of Nano-mechanical items.

Other promising utilization of Nanotechnology is the amalgamation of the worth incredible and more grounded bundling substances for higher capacity of food and improving their time span of usability. Regardless of such helpful and capacity bundles, there is a requirement for contrasting the effect of recently orchestrated Nanomaterials. Because of the perils of NPs on the plant, there is a need of examination that permits shrewd utilization of Nanoparticles. Impact of Nanoparticles can be superb or negative contingent on the plant species, focus and type of NPs, season of treatment, level of advancement of the plant, and loads of different components. Since the effect on vegetation is on the double identified with environmental factors and creature wellbeing, the issues identified with security should be tended to. Nanotechnology, almost certainly, guarantees amazing redesigns in farming area without bounty negative effect on the climate.

References

1. X. Diao, P. Hazell, and J. Thurlow, "The Role of Agriculture in African Development," World Dev., 2010, doi: 10.1016/j.worlddev.2009.06.011.

2. B. M. Campbell, P. Thornton, R. Zougmoré, P. van Asten, and L. Lipper, "Sustainable intensification: What is its role in climate smart agriculture?," Current Opinion in Environmental Sustainability. 2014, doi: 10.1016/j.cosust.2014.07.002.

3. L. F. Fraceto, R. Grillo, G. A. de Medeiros, V. Scognamiglio, G. Rea, and C. Bartolucci, "Nanotechnology in agriculture: Which innovation potential does it have?," Front. Environ. Sci., 2016, doi: 10.3389/fenvs.2016.00020.

4. N. Sertova, "Application of nanotechnology in detection of mycotoxins and in agricultural sector," J. Cent. Eur. Agric., 2015, doi: 10.5513/jcea01/16.2.1597.

5. R. Grillo, P. C. Abhilash, and L. F. Fraceto, "Nanotechnology applied to bio-encapsulation of pesticides," J. Nanosci. Nanotechnol., 2016, doi: 10.1166/jnn.2016.12332.

6. R. Dixit et al., "Bioremediation of heavy metals from soil and aquatic environment: An overview of principles and criteria of fundamental processes," Sustainability (Switzerland). 2015, doi: 10.3390/su7022189.

7. J. Rodríguez, M. J. Martín, M. A. Ruiz, and B. Clares, "Current encapsulation strategies for bioactive oils: From alimentary to pharmaceutical perspectives," Food Research International. 2016, doi: 10.1016/j.foodres.2016.01.032.

8. M. Ozdemir and T. Kemerli, "Innovative applications of micro and nanoencapsulation in food packaging," in Encapsulation and Controlled Release Technologies in Food Systems: Second Edition, 2016.

9. P. Vartholomeos, M. Fruchard, A. Ferreira, and C. Mavroidis, "MRI-Guided Nanorobotic Systems for Therapeutic and Diagnostic Applications," Annu. Rev. Biomed. Eng., 2011, doi: 10.1146/annurev-bioeng-071910-124724.

A. Martirosyan and Y. J. Schneider, "Engineered nanomaterials in food: Implications for food safety and consumer health," International Journal of Environmental Research and Public Health. 2014, doi: 10.3390/ijerph110605720.

10. Gupta, H. B. Eral, T. A. Hatton, and P. S. Doyle, "Nanoemulsions: Formation, properties and applications," Soft Matter. 2016, doi: 10.1039/c5sm02958a.

11. M. Thiruvengadam, G. Rajakumar, and I. M. Chung, "Nanotechnology: current uses and future applications in the food industry," 3 Biotech. 2018, doi: 10.1007/s13205-018-1104-7.

12. S. Sagadevan and M. Periasamy, "Recent trends in nanobiosensors and their applications -A review," Rev. Adv. Mater. Sci., 2014.

13. W. Du et al., "Interaction of metal oxide nanoparticles with higher terrestrial plants: Physiological and biochemical aspects," Plant Physiology and Biochemistry. 2017, doi: 10.1016/j.plaphy.2016.04.024.