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Review Article

New Insights for Improving Agriculture Soils through Nanotechnology

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Abstract

Different efforts have been made especially in the fields of nanotechnology that employed various combinations of nanoparticles to overcome the stresses occurred in the agricultural lands. Nanoparticles that potentially designed through nanotechnology applied to the soil in the form nanofertilizers that increased the yield also good impact on soil composition. Application of nano-SiO_2 improves also seed germination throiugh rooting applications, chlorophyll content with proline accumulation. Soil composition also improved the overall fruits and vegetables varieties in such a way that nanoparticles makes intact combinations with inner layers of soil. Biological applications of iron sulfate ($FeSO_4$) in the form of foliar spray also showed excellent resistance to the salinity stress tolerance in the case of sunflower cultivars. Nano zeolite; another type of newly modified materials efficient for long term delivery of nutrients and minerals in soil composition and mineral balance ensures for plant growth. Nanopesticides can be used for efficient crop protection also promote plant stress tolerance and soil enhancement. Nano-Si that improves the various other stresses in plants species such as nickle and chromium. Nanotechnology has several advantages over other technologies due to cost efficient and simple to use and imply on more effective treatment and remediation methods.

Keywords: Nanotechnology, agricultural lands, iron sulfate, foliar sparay, sunflower cultivars.

INTRODUCTION

Soil salinity is one of the major cause of soil erosion that damage the earth surface and nearby areas. Thus, it widely affected the overall growth of plants and young growing tissues. Climate change also another cause affecting the soil composition in the baseline of climate over time spans, such as temperatures affected soil composition, water deficiency, cold, salinity, alkalinity and environmental pollution with toxic metals [1-3]. Therfore, there is need for advanced technology that overcomes the issues related to soil salinity and urbanization. Water deficit stress or sometimes flooded threatening also disturbed the natural life of water balance that affected the overall soil structure. Different efforts have been made especially in the fields of nanotechnology that employed various combinations of nanoparticles to overcome the stresses occurred in the agricultural lands [4, 5].

Nanoparticles that potentially designed through nanotechnology applied to the soil in the form nanofertilizers that increased the yield also good impact on soil composition. Nanoparticles applications also improved properties of soil include color, texture, structure, porosity, density, consistence, aggregate stability, and temperature. These properties affect processes such as infiltration, erosion, nutrient cycling, and biologic activity. Salinity that stress seriously limits crop production also lower the agricultural yield. It was found that application of nano-SiO_2 improves also seed germination through rooting applications chlorophyll content with proline accumulation in tomato. Soil composition also improved the overall fruits and vegetables varieties in such a way that nanoparticles

makes intact combinations with inner layers of soil. It was also believed that nanoparticles also penetrated to inner roots and higher concentrations is lethal to the soil. It also leads to the soil toxicities [6-9].

Diffrenet types of nanoparticles played important roles in soil composition and also works against soil salinity. The most important nanoparticles in soil applications are silver and silica based that also controlled the soil degradations. Biological applications of iron sulfate ($FeSO_4$) in the form of foliar sparay also showed excellent resistance to the salinity stress tolerance in the case of sunflower cultivars. Nanotechnology have made tremendous achievements in soil sciences and agriculture as nanoparticles also improved the uptake of different kinds of minerals essential for the growth of plants. It also positively influence on chlophyll growth photochemical efficiency of photosystem II. It has been obersved that applications of silicon nano-particles (SiNPs) also effectively alleviate the UV-B induced stress in foliar appliactions in case of wheat crops [10, 11].

Agriculture Practices for Soils Improvement through Nanotechnology

Nano zeolite; another type of newly modified materials efficient for long term delivery of nutrients and minerals in such a way that soil composition and mineral balance ensures for plant growth. These nanomaterials also played important role in acceleration of plant growth and productivity as effective tools in agricultural practices also enhace the resistance in drought-prone. These advances in agriculture leads to development of biofortied crops that are vital for sustainable crop production. While, other types of nanomaterials are nano-Si fertilizers are used for controlling the soil remediation and thus prefer over traditional fertilizers in reducing heavy metal accumulation. Potential use of nanotechnology is vital as compared to other technologies as it is widely employed transport of nanoparticles that deliver to plant tissues. These nanoparticles are less toxic and environmental friendly. Uses of nanosensors and computerized controls greatly contribute to precision farming [12-14].

Delivery of nanomaterials is efficient as it provides the adsorption of most materials applied through sprays. The mosy improvement has observed in soil proerties as crops grow accelerate the proecss of agricultural products. Nano-based target delivery approach in the form of gene transfer is most suitable both for soil and for crop improvement. It also improves the soil nutrition balance by promoting the update nutriens. Metal absorption in modern environment also causes disturbing soil nutrition balance by lowering the efficacy of update nutriens. Nanopesticides can be used for efficient crop protection also promote plant stress tolerance and soil enhancement. Uptake efficacy of minerals is essential for plant growth as most of developmental stages depends on it. Most of products and nutrients levels to increase the productivity without decontamination of soils, waters, and protection against several insect pest and microbial diseases. Due to deficiency of minerals, growth of plants stunt due to loss of uptake power of minerals [15, 16].

Nanoparticles that applied to soil in appropriate ways enhanced the growtha and soil properties. One of ideal example is nano-Si that is used for removal of toxic metals in soil. As accumulated toxic metals can cause serious toxicities in various plant tissues. As a result, plants are unable to growth in environment of reactive oxygen species. Nano-Si that improves the cadmium stress in rice plants by regulating Cd accumulation. Nano-Si that improves the various other stresses in plants species such as nickle and chromium. Silica based nanoparticles accumulated in plant tissues that promoted the plant growth while on the other hand, toxic metals are also accumulated in plant tissues that retarted the plant growth. So, nanotechnology has played an important role in soil practices by improving the soil structure and premeditation [16-18].

Different methods are used for soil remediation but most of them have serious drawbacks. These are chemical and phyical based in which chemicals in the form of sprays and liquids form applied to the soil. The concentrations of these chemicals appplied affected the soil properties. Low concentration is effective for plant and soil health as uptake efficacy not significant. High concentration is not effective as it damage the soil also injurious to the soil health as uptake efficacy not significant. While, optimum concentration is effective for plant and soil health as uptake efficacy highly significant in environment stresses. Titanium dioxide is one of the most produced nanomaterials and therefore potentially the most released nanoform in soil that is effective for meeting the current demands of soil fertility. Thus, it also counters the soil salanity that affect the major part of agriculture land [19-22].

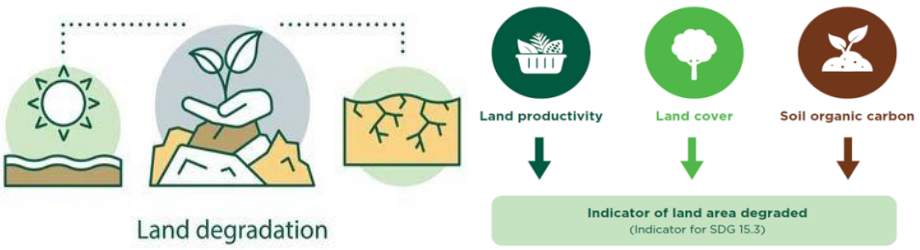

Fig 1: Shows the events of degradation of soil

Optimum level also enhance the defense systems in plants counters the atatck of different insects. Nanofertilizers are also effective for the loss of soil damage also control the loss off fertilizers; magnetic fertilizers or nanocomposite fertilizers which use a nanodevice to supply a wide range of macronutrient and micronutrients in desirable concentration. Therefore, nanotechnolgy has made significant improvements in soil applications in removing of heavaly metals that can be easily eliminated with nano-based techniques such as nano fertilizers, nano biosensors, nano pesticides, and different nano-remediation processes. Nanofertilizers and biochemical applications of nanomaterials are efficient ways for delivering the chemicals as compared to the other traditional methods. As tradionally used methods for soil applications have serious environmental hazards thus prohibited in terms of prolonged to the soil. These methods have been replaced with nanotechnology based methods that are effective for soil nutritional products [22-24].

Mechanisms of action of nanomaterials to the soil applications explored in terms of interparticle diffusion distance, redox reactions, adsorption, ion exchange and electrostatic interaction that make these materials appropriate catalysts for the remission of the concerned soil pollutants. As these nanoparticles facilitates the interaction in development stages thus helpful for enhancing the overall agriculture yield. The fact of action of nanoparticles to the soil is that nanoparticles act to surface of plant tissues where applied that degrades the toxic metals causing metal toxicity thus lower the risk of environmental risks. Second aspect is that they make the intact combinations with plant tissues by promting their growth and inhibited the growth of attacking insects. So, they have dual action on maintaining the soil structure [24-28].

Table-1: Shows the Soils Improvement through Nanotechnology

Nanoparticles Type	Application	Usage	Soil Applications
Silica based	Seed germination	Chlorophyll content with proline accumulation	Soil composition also improved
Iron sulfate	unflower cultivars	Excellent resistance to the salinity stress	Soil Layering and Composition
Nano zeolite	For long term delivery of nutrients and minerals	Agricultural practices also enhace the resistance in drought	Soil composition also improved
Nano-Si	Remediation	Regulating Cd accumulation	Soil Remediation
Nanofertilizers	ffective for the loss of soil damage	Heavaly metals that can be easily eliminated	Soil composition also improved

Various combinations of organic, metallic and inorganic, and bioinspired nanoparticles have been made in order to increase the delivery problems associated with traditional methods. These newly developed nanoparticles are natural short-ordered aluminosilicate, the surface of titanium oxide, and humic acids can be coupled with Ni through a multiwalled carbon nanotube. These also apllied in a wide range of macronutrient and micronutrients in desirable concentration keeping the concentration at optimum level. Bioorganic metallic nanoparticles interaction with soil layer is also facilitates the bioabsorption of nutrients and essentials minerals that strengthens the root system. While on the other hand, inorganic nanoparticles also effective for soil fertility but combinations also make the intact with soil structure [29-32].

Nanotechnology also improve the soil layer capacity resistant to tolerance of crops that reduced the chances of bioaccumulation various anions casuing the inceasing damage to rooting system. These ions are SO_4^{2-} and Cl^- as well as cations of Na^+, Mg^{2+}, and Ca^{2+}. The excessive amount of these ions casuing the risks of environmental hazards and salinity. Nanotechnology monitors, another revolutionary advancements and leading agricultural controlling process and many potential benefits such as enhancement of food quality and safety, reduction of agricultural inputs, enrichment of absorbing nanoscale nutrients from the soil [32-34].

Biochemical and agricultural applications of nanoparticles with bioavailability makes them ideal for soil and enrichment with high abundance of minerals. One of the wildey used nanoparticles is the CeO_2 based nanoprticles that enhance the resistance to insects, harsh conditions and salt tolerance by enabling the better ability to maintain the cytosolic K^+/Na^+ ratio in cotton. While, other examples are the use of seed priming based nanoparticles designed through metallic coating. These coating is effective that helps to grow the useful bacteria that makes the mutualistic relationship with the planst. Nanoceria seed priming is the main and best exmaple that improves salt tolerance through modulating the α-amylase activities and ROS homeostasis in rapeseed. The lowering oxidation in plants also resist to patholgical changes [1, 3, 7, 8].

Nanoparticles also played important role in activating the activities of antioxidant enzymes. These enzyms are activated in the form of nano-enzymes that can scavenge from oxidative stress. These nanoenzymes also involved in mitigation of oxidation stress, role in soil remediation and maintained plant activities under the harsh conditions of nutrient deficiency, salinity, water, drought, and heat. These also leads to the stimulation of antioxidants enxmyes in plants like superoxide dismutase (SOD), peroxidase (POD), catalase (CAT), ascorbate peroxidase (APX), and glutathione peroxidase. Soil pollution which is major problems of the global level that can be overcome with advanced technologies [9, 11, 17].

Several mechanisms are involved once there is soil damaged and plant activities diminished udner the stress conditions. The damaging soil also activates the reaction oxygen species that are causing the oxidative stress in plants. Different plant organelles unable to perform their functions in efective way which can leads to the more production lipids causing the damage the different parts of plants. These unfavorable conditions decreased the overall survival rate of plants. It also altar the soil pH affects nutrients available for plant growth which makes the less availbility of calcium, phosphorus, and magnesium to the plant [11, 17, 19].

Different agricutural advances with intergrative strategies also helpful for controlling the remediation and other soil damaging problems. One of the ideal example is the cucumber plants in which spray of foliar-delivered Mn_3O_4 nanoparticles leads to also activates the reaction oxygen species that are causing the oxidative stress in plants also stimulators for the bioactivation of defense sytem in plants such as stimulation of antioxidants enxmyes in plants like superoxide dismutase, peroxidase, catalase, ascorbate peroxidase, and glutathione peroxidase. Different genes are activated in the soil pollution problems which can repressed the functions of plants tissues. Therefore, there is important to increase the overall yield through controlling the environmental pollution which can increase the growth of newly developed plant varieties in soil. It also improving the ability to maintain ROS homeostasis could be one of the important mechanisms under nano-enabled plant salt tolerance [22, 28, 29].

CONCLUSION

Soil pollution is one of the most important environmental issue that needed to resolve through advanced technolgies. One of the latest technolgy is nanoparticles based used for solving the challenges of contamination of soil with heavy metals, pesticides, and persistent organic pollutants. Nanotechnology has several advantages over other technologies due to cost efficient and simple to use and imply on more effective treatment and remediation methods. This review will be helpful for discovering the novel nanoparticles with applications for biological and agricultural advances in soil remediation.

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