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Effects of Nano Fertilizers Technology on Agriculture Production

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Abstract

nanotechnology has the ability to produce new revolutionary forms of fertilizers, such as NFs, to increase global food supply to feed the rising world population. NFs have potential as part of smart crop production systems in the context of sustainable agriculture, Since they have wide surface areas and a characteristic gradual, steady release of nutrients. These exciting features make them highly desirable for use in modern agriculture.

The use of NFs can improve agricultural production and resistance to biotic and abiotic stress. Consequently, the use of NFs in the agriculture sector cannot be avoided.

The usage of NFs can help to reduce the amount of fertilizers through the smart distribution of active compounds, increase nutrient availability and NUE values, and reduce fertilizer losses due to volatilization, leaching, leakage and energy consumption during production. Besides that, the use of seed coatings with NFs can reduce the costs of crop yields and the ecosystem.

NFs can release their nutrients in 40–50 days, while synthetic fertilizers can release their nutrients in 4–10 days. Synthetic fertilizers, especially N-urea, can rapidly lose more than 50% of the nutrient content after field application. The foliar application of NFs is much easier and superior to the soil application of NFs.

key words: Nano technology, synthetic fertilizer, Nano-fertilizer.

Introduction .

Agriculture is the main source of income in Developing economies, supplying food and animal feed. Globally, a large proportion of people face daily food shortages due to changing agro climatic conditions, especially in developed countries. The condition in developed countries is even poor. Drought and pest-resistant crops with improved mineral absorption are therefore required to optimize production levels. Alfadul (2017)

Food security is one of the most important issues for any country. In the future, global food and nutrition demands will rise by 70 per cent from current levels in a balanced manner by 2050. (Chen and Yada, 2011). Farmers must also have new and innovations and follow modern agricultural solutions to evaluate the potential demands of food production dependent on agriculture (Mukhopadhyay,2014).

according to this nutrition demands Its requires more food production in terms of quantity and quality of food and this Production needs to meet the nutritional requirements of the crops .One of these requirements is cultivated with micro-nutrients. that Consuming food products with low nutrient content will introduce more people, especially Younger people , small children, to different diseases , improve the nutritional content will reduce these diseases or undernourishment diseases in general (Ali ,2016 and Salman ,2016)

Production Agricultural products (agricultural crops such as vegetables, fruits and animal feed) in high quantities and of good quality that depend mainly on the availability of balanced quantities of macronutrients and micronutrients. And balance here does not mean equal quantities, but rather the availability of all the necessary nutrients in ideal quantities) with sufficient limits to grow without any deficiency Specific to growth) and by processing that is consistent with the requirements of the specific crop growth, especially the high-yielding varieties .It varies by soil, crop, crop type and variety The surrounding environmental conditions, soil management method, and the type of macro and micro fertilizers and their sources (Ali *et al*,2015 and Panuccio *etal* , 2009).

Over the last decades, the chemical fertilizer industry has become one of the main issues in modern agriculture in order to increase crop production and enhancing the soil with mineral nutrients that could be exhausted from the soil by intensive land use. In order to achieve the best results from the utilization of fertilizers in agriculture, Fertilizers should be applied to the soil according to established qualitative and quantities, which should be tailored to the needs of developing plants and their development phases. Over the years, though, the excessive usage and abuse of chemical fertilizers has resulted in numerous environmental and health damages that need to be controlled and measured in order to minimize them and prevent the complete deterioration of arable property (Khaled 2018).

It is time to use new technologies, such as biotechnology and nanotechnology, to maintain the ever-increasing market for food crops. Nanotechnology is classified as a branch of science which deals with the understanding and control of matter in dimensions of approximately 1-100 nm and its implications for the welfare of human beings (US Environmental Protection Agency).

The word 'nanotechnology' was invented for the first time by Norio Taniguichi, professor at Tokyo University of Science, in 1974 (Khan and Rizvi ,2014). While the word 'nanotechnology' has long been introduced in several fields, the suggestion that nanoparticles (NPs) may be of importance to agricultural production is a new revolutionary technology and is still under development(Gogos *etal*,2012).

Nano Fertilizer In Agriculture

increasing in soil fertilizers is important to supplement soil fertility for better food crop yields (Barker and Pilbeam, 2006). The use of chemical fertilizers, produces numerous detrimental environmental consequences and has harmed the health of the soil. A new cost-effective eco-friendly technique for better crop production is therefore needed. In this case, instead of using synthetic fertilizers, the use of nano-fertilizers can help control the leakage of nutrients into the soil and reduce losses due to chemical fertilizers (Naderi and Abedi, 2012; Moaveni and Kheiri, 2011).

The use of modified nanomaterials in the sustainable agriculture has demonstrated a radically new way of producing food that could theoretically solve the uncertainty in the crop field with minimal available resources(Godfry *etal*,2010).

The development in green nanotechnology has significantly changed the world. Agriculture canvasses and nanomaterials as Nano fertilizers have made commitments to achieve the projection of global food production and sustainable agriculture. Nano fertilizers can be the perfect option for alleviating macro-and micro-nutrient shortage by enhancing the quality of nutrient usage and solving persistent eutrophication problems (Shukla etal ,2019).

Nutrients can be caught in nano-fertilization by using nano-materials coated with a thin film or provided as emulsions. The gradual release of nutrients from fertilizers covered with nanoparticles increase the efficiency of the use of nutrients in crops. (El-The-Ramady ,2014).

characterization of Nanomaterials and Nanoparticles

Nanoparticles display remarkable characteristics that are not otherwise displayed by materials. figure (1) For instance, surface area, cation exchange capability, ion ,adsorption, complexion, several other properties of clays will multiply if taken to nano-size (Mukhopadhyay 2014).

Nanoparticles are shaped products small micronutrient capsules or capsules with many nutritional properties, namely: 1) Improvement of the contact surface for absorption and thus increased vital readiness. 2) Reduction Production costs. 3) for safe food and environmental biodegradation, (Moslemi *et al*.2014).

Nanoparticles can have varying surface structure, shapes, densities, and reactions to processes such as adsorption and redox reactions. These particles have a large percentage of atoms present on their surface that could be used to synthesize agricultural nanomaterials (Maurice and Hochella 2008; Waychunas *et al*., 2005).

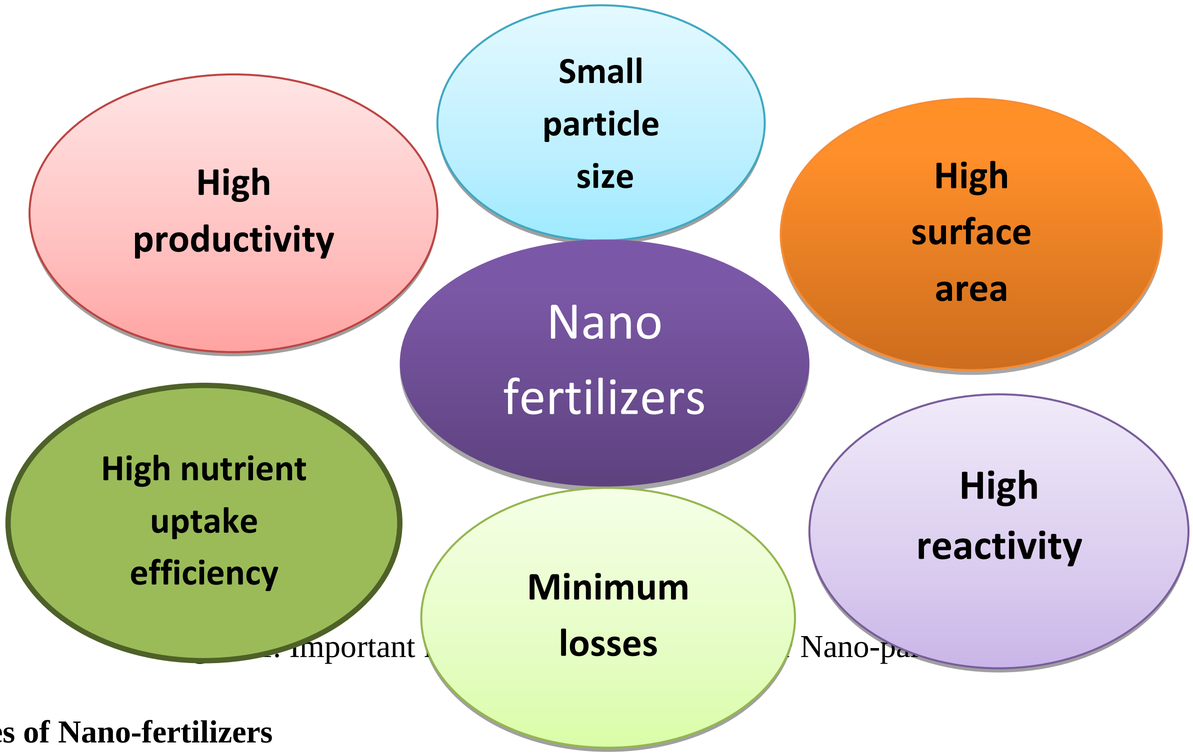
Ghorbani *et al*. (2011) stated that nanoparticles (NPs) at a scale of less than 100 nanometers exhibit material properties that differ from them when they are of conventional dimensions greater than 100 nm.

Peddis *et al*. (2009) explained that there are some unique properties of nanoparticles such as very high specific surface area and high surface energy. This leads to a large difference in their behavior and environmental fate in relation to larger molecular isotopes.

Nair *et al*.(2010) show that nanomaterials possess all the properties necessary for their use in cultivation, such as effective concentration with high solubility, stability and good efficacy, in addition to control over time liberally, as it is less toxic and safe, and is used in small quantities and avoids repeated application on plants, and then get a good result from the first application, as it has the ability to enhance the plant's ability

In the rapid absorption of nutrients and other smart sensors that for use against viruses and treatment of pathogens of other crops,(Thul *et al*., 2013).

Musante,(2011) indicated that some materials at the nanoscale show a change in the surface area, the degree of freezing or melting, and some other properties compared to the aggregation of particles at a higher level.



Important … Nano-pa…

Uses of Nano-fertilizers

Despite the availability of various mineral and chelating fertilizer sources for nutrients and the availability of Different addition methods (in addition to soil or spraying on leaves, or both together), but the efficiency of using these fertilizers does not exceed 5% of the additive. Nano fertilizers play roles in plant nutrition, either when sprayed on leaves or they are added through ground treatments, and the Nano fertilizers are distinguished by being more soluble and active than the traditional fertilizer particles.(Jpallavi and Rameshaiah 2015).

Nano fertilizer sends nutrients to the plant through one of three methods:

1) as mineral nutrients can be encapsulated inside nanomaterials such as nanotubes .2) materials with open nanoporous structure, and then be coated with a thin film of protective polymer. 3)They are sent in the form of particles or emulsions whose dimensions are in the dimensions of the nanoscale and due to their possession of a very large specific surface area compared to the total size, the effectiveness of nanoparticles may exceed the effectiveness of the more innovative conventional polymer-coated fertilizers, which have witnessed a great improvement in the past years (Derosa *et al*., 2010,)

Currently, there are different types of nutrients that the plant needs, whether major or minor elements in the nanoscale, which allows them to be used in many crops, whether field

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crops or Horticultural products such as nitrogen, phosphorous, potassium, iron, zinc, calcium and others .(Tarafdar. *et al*,2014).

Smart Delivery Systems

In the future, nanoscale machines with novel properties may be used to make agricultural systems smart. For example, machinery may be used to detect plant health problems before they became apparent to the farmer. Such devices may be able to adapt to various circumstances by taking effective remedial steps. If not, the farmer will be alerted to the problem.

In this way, smart machines can serve as a prevention and early warning mechanism. Such techniques could be used to distribute chemicals in a controlled and targeted method in the same manner as nanomedicine has consequences for human drug delivery.(Jpallavi and Rameshaiah 2015).

Types of Nano fertilizers (NFs)

NFs can be derived from synthetic compounds (i.e. modified types of synthetic fertilizers) or from different parts of plants using various chemical, mechanical or biological methods using nanotechnology,There are two main types to nanoparticle synthesis: (i) the top to the bottom and (ii) the bottom to the top type. (Singh and Kumar ,2017).

Nanoparticles are prepared in the top-bottom type by breaking down the material into nano-sized particles. Nanoparticles are synthesized from atoms, molecules, and smaller monomers in the bottom-top type. Green Synthesis is a non-toxic and environmentally safe process since it utilizes bio-organisms such as plants, fungi and bacteria for the synthesis of nanoparticles, These micro-organisms are both decreasing and stabilizing agents, and no hazardous compounds or chemicals are used(Lee ,*etal*.2020). On the other hand, a chemical process that may be a top-bottom or bottom-top types use metal components, reducing agents, and toxic chemicals for the stabilization of nanomaterials that tend to damaging effects on humans and the ecosystem when disposed of (Iravani,etal.2015).

Various forms of NFs are produced depending on the substance or carrier found in them, e.g. hydroxyapatite nanoparticles, zeolite, mesoporous silica nanoparticles, nitrogen, copper, zinc, silica, carbon and polymeric nanoparticles (Guo, *etal*.2018)

Efficacy of Nano fertilizers against synthetic fertilizer on plants

Since most of these nutrients are not easily consumed by plants, farmers prefer to use large doses of fertilizer to partly remediate their poor nutrient values, resulting in a famously damaging effects on land, water and the environment. The use of NFs will increase the nutrient of fertilizers, increase crop yield and efficiency, and minimize the adverse effects of synthetic fertilizers (Czymmek, et al.2020).

Nitrogen, known to be the most essential mineral resource for plants, is a critical component of many amino acids, proteins, DNA, ATP, chlorophylls, and cell structural units. Plants take N in the form of NO−3 and NH+4. One of the biggest challenges of synthetic N

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fertilizers is the high volatilization and leaching rates that occur during and directly after field application. An N-NF developed by coating urea onto Nano-film was successfully used in *Brassica napus L*. In conclusion, nitrogen in the form of NFs is highly recommended because it can cause a slow release of N, reduce volatilization and leaching rates, lead to a high nutrient uptake, and improve the growth and productivity of crops. (Derosa *et al*., 2010 and Preetha and Balakrishnan,2017)

phosphorus (P) is considered to be the second most vital nutrient for optimum plant growth. P in synthetic fertilizers is poorly available due to its slow releasing time and high fixation in soils. NFs or slow-release materials like zeolites may have the potential to increase the nutrients of P for several field crops. P applied in the form of NFs can be a suitable option, particularly in smart agriculture, because it has a slow-release material over a long period, and it can reduce the leaching of P into groundwater and enhance the productivity and quality of crops. A biosafe nano fertilizer, a source of P, was found to significantly increase fresh and dry biomass, increase fruit yield, and improve quality , Recent research have shown that NFs will steadily deliver P up to 40–50 days after application, while typical P synthetic fertilizers deliver all nutrients within 8–10 days of application(Liu and Lal,2015)

Potassium (K) is the third largest macronutrient after N and P. Plants with a sufficient quantity of K have been found to be more resistant to abiotic stress, such as water stress. K deficiency adversely affects root shoot growth, the amount of seeds within the fruit, the scale, form, color, taste and the final yield of the crop researched and developed a nano-potassium fertilizer formulation with a gradual release rate of K. Nano-K NFs have been shown to preserve soil health and enhance water quality by reducing K loses in soil and contributing to improved physiological and yield characteristics.(. Kubavat *etal*,.2020)

Micronutrients are also important to improve plant production and efficiency. Nano-sized structures can improve their solubility and bioavailability. This will improve the uniform dispersion of these nutrients in the soil. Adsorption and attachment of micronutrients to soil colloids can also be minimized.(Seleiman,*etal*.2012).

Zinc: Plant growth relies heavily on Zn nutrition because Zn is a structural part of the co-factor of different proteins and enzymes. Zinc NFs in the type of ZnO are widely used in modern agriculture because they're more efficient and cost-effective than synthetic Zn fertilizers.(Seleiman,*etal*.2020). However, trace elements such as zn may have an adverse impact on plant growth by creating certain metabolic alterations in plants as administered at elevated doses. Studies have shown that the use of Zn NFs can improve germination, seedling growth, yield and crop quality, but may also have negative effects on growth characteristics. In summary, Zn NFs increase growth, boost yield and efficiency, and are more cost-effective than synthetic fertilizers.(Singh *etal*. 2013)

Iron (Fe) is an essential nutrient involved in the synthesis of chlorophyll, DNA, chloroplastic composition, respiration, and many metabolic pathways. Fe insufficiency or

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abundance has adverse effects on the physiological and metabolic processes of plants, Fe abundance in well-aerated soils is typically high, but usually forms insoluble ferric compounds at neutral pH values, As a result, Fe-enriched fertilizers could maximize the supply of Fe plants to improve plant output. Fe NFs can be an optimal alternative source for Fe, especially in soils suffering from Fe deficiency.(Palmqvist,*etal*.2017).

Fe NFs increased germination and better crop growth relative to synthetic Fe sources.(Srivastava, *etal*.2014) have reported that iron pyrite NPs have increased spinach growth (Spinacia oleracea L.)

Manganese Mn is an important micronutrient involved in the metabolism of N, photosynthesis and biosynthesis of fatty acids, ATPs and proteins. Despite this, and based on the chemical structure of the acidic soil, Mn can be poisonous to various plants.(Palmqvist,*etal*.2017).

Research has shown that the use of Mn greatly increases the growth and yield of wheat, corn, sugar cane, soybean and common beans. (Fageria, 2001), Researches on nano-Mn fertilizers or Mn NPs on various plants have shown that nano-Mn treatments can increase the root and shoot growth of mung bean by 52% and 38%, respectively, comparison with control treatment (MnSO4; available commercially as manganese salt at the suggested dose. (Pradhan,*etal*.2013)

Copper (CU) deficiency of copper leads to a variety of abnormalities; necrosis; stunted growth; low quantities of seeds, grains and fruits; and finally low yields of crops (Rai,*etal*. 2018).

The composition of soil organic matter influences the supply of Cu, so the application of Cu NPs to soil can be helpful due to their wide surface area, high solubility and reactivity(Hong, etal.2015).

In recent research, the field application of the CuO NPs nanofertilizer increased the germination and root growth of soya beans and chickpeas (Cicer arietinum L) (Adhikari, etal.2015)..

Boron (B) is an essential micronutrient that plays a significant role in the elongation of pollen grains and tubes, the development of cell walls, the transition of photosynthetic species from leaves to active sites, and the increase in flowers and fruit yields. Researches have shown that Boron Nano-Fertilizer and Nano-Particles can boost plant growth and increase yield (Davarpanah, etal.2015).

Disadvantage of Nano-fertilizer

Nano-Fertilizer and Nano-Particles technologies have a clear potential to revolutionize the agriculture sector and its productivity. There are various safety and ethical issues pertaining to the application of NFs or NPs in agriculture systems. exposure to NPs and NFs could result in health risks. NPs can alter gene expression in animals because of their size which allows them to enter different animal tissues, cells, and organelles and then interact with DNA (Xia and Nel,2009). The use of supra-optimum application rates may lead to the deposition of Nano-based macro and micronutrients and cause Nano toxicity and a reduction of water quality.(Chhipa,20017).

NPs influence living organisms in a number of different ways, e.g. carbon-based NPs change the DNA structure and gene expression levels in plant tissues (Lahiani, etal.2015 and , Zuverza, etal.2017). ZnO NPs impact symbiotic connections in legumes and prolong the mechanism of nitrogen fixation(Huang, etal.2014). They also create dietary imbalances and trigger molecular modifications in plants, e.g. CuO NPs have been shown to affect hormone balance (e.g. indole-3-acetic acid and abscisic acid) in plants(Le Van, etal.2016).

Iron-based nanomaterials impair the hydraulic conductivity of roots due to particle accumulation on the root surface, which results in a poor absorption of water and nutrients such as Ca, K, Mg and S (Martinez and Barroso,2016).

conclusion

nanotechnology has the potential to develop new innovative types of fertilizers such as NFs to increase global food production to feed the increasing world population.

NFs have potential as part of smart crop production systems under the framework of sustainable agriculture because they have large surface areas and a characteristic slow and steady release of nutrients.

These promising characteristics make them highly suitable for use in modern agriculture.

Furthermore, the use of seed coatings with NFs and nanosensors may decrease the costs of agricultural production and environmental issues.

NFs can release their nutrients in 40–50 days, while synthetic fertilizers do the same in 4–10 days.

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