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# USE OF NANO-FERTILIZERS FOR ENHANCING NUTRIENT USE EFFICIENCY AND AGRICULTURAL CROP PRODUCTIVITY

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## Abstract

The continuous increase in the world population requires the provision of high rates of agricultural crop production to fulfill the mass need for more food for people, and this must be done using intensive agriculture systems that depend on adding large amounts of chemical fertilizers per unit area without caring for natural resources and ecosystems, this has led to many problems, including a decrease of fertilizer use efficiency and increased production costs. Using nanofertilizers in agriculture is one of the options available to enhance agricultural production, provide enough food for the rapidly growing world population, solve environmental problems, and protect natural resources, due to the unique properties possessed by these nanotechnology fertilizers, it can improve nutrient use efficiency, reduce its loss by various pathways and the degree of impact on environmental pollution, which increases the efficiency of growth and productivity of crops. also using nano-fertilizers are cheaper than traditional chemicals.

***Keywords: nanofertilizer, nanoparticles, use efficiency, absorption, production***

## Introduction

Today, agriculture faces demands that agricultural development is more economically and efficient in food production. Modern trends in the prevention of pollution by the increasing population with shrinking arable land and water resources (Prasad *et al.* 2014). Fertilizers are natural or synthetic materials that are applied to soil and crop systems to provide the necessary nutrients for plant growth, development, and yield enhancement (Ali, 2012). First of all, in the international arena; commercial fertilizers are indispensable for nitrogen (N), phosphorus (P), and potassium( K) which form the main component of the fertilizer industry world. However, more than 50% of the traditional addition of fertilizers is lost through volatilization, leaching, or precipitation, which reduces the benefit of plants from them, and this leads to severe economic and environmental consequences, as the loss of half of the nitrogen fertilizer added to agricultural lands in water, air and other processes**,** leading to harmful environmental such as nitrates leaching into ecosystems and nitrogen oxides released in the atmosphere (Burhan, 2018). Nanotechnology has been proposed as one of the important solutions to increase agricultural production by producing more quantities with lower costs and reducing energy consumption, which in turn can lead to a significant reduction in rates of environmental pollution. Nanofertilizers are considered one of the important applications of this technology in the agricultural field, which appeared to have great potential in enhancing crop growth and productivity, as it could be a mechanism that contributes toward tackling the hurdles facing farmers in crop management on obtaining high-yielding crops with reduced application of manufactured chemical fertilizers (Mahmoud *et al.* 2017). Nano-fertilizers are modified fertilizers using chemical, physical, or biological methods to enhance their properties and components to improve crop productivity, which has at least one of its dimensions on the nanoscale (less than 100 nanometers) in the form of micro or macro nutrients or loaded with nanoparticles. So it can be a viable alternative to traditional chemical fertilizers, due to the different mechanisms of action of these fertilizers in delivering nutrients to the plant, increasing the efficiency of fertilizer use, lowering nutrient loss, and reducing environmental pollution, as well as the lowest economic cost, it can be a successful alternative over traditional chemical fertilizers, As it was noted that

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the use of these fertilizers manufactured at the nanoscale had a positive impact on the growth and yield of plants, due to the unique properties that these fertilizers possess that lead to the adjustment of the physical and chemical characteristics of the plant (Rai, 2015).

**PROPERTIES OF NANOFERTILIZERS**

For solid nano fertilizers, their properties are evaluated by a scanning electron microscope (SEM), and in liquid state line is estimated using transmission electron microscope (TEM) (Khandelwal & Joshi, 2018). The application of nano-sized fertilizers is a mean replacement for traditional fertilization methods due to their size below 100 nanometers, an enhancement in the surface area allowing many metabolic processes occurring inside the plant leading thus achieve multiple benefits. Also the small size of the fertilizers increases their solubility, which facilitates their penetration to the plant surface, whether they are used by adding to the soil or spraying on the leaves because their size is less than the pores of the roots and leaves, which increases their ability to penetrate plant surfaces as well as the controlled release in the process of directing these nutrients, with effective concentration, low toxicity and easy nutrient delivery to target sites, which increases plant response for easy entry into cells and thus improves nutrient uptake efficiency (Singh, 2017). The most important roles played by nano-fertilizers, whether they are sprayed on the shoots or added to the soil, can be summarized in the following points:

1. Increase the activity of metabolic processes and photosynthesis in the plant by increasing the content of leaves of chlorophyll.
2. Nano-fertilizers help in the betterment of soil properties and the holding capacity of water.
3. . Fast absorption, which allows it to be used as a spray on the plant to provide the actual needs of the plant faster.

4. Use of nano-fertilizers helps to minimize the energy used, due to using limited quantities per unit area compared with common fertilizers that harm natural habitats and others.

5. Increased productivity compared to traditional fertilizers and lower costs, which gives higher profitability to farmers.

6. Alleviating air, water, and soil nutrient losses with an immediate crop benefit.

7. Enhances plant's protection against diseases and tolerating other stress conditions, to which they are exposed under insufficient environmental conditions.

8. The use of nano-fertilizers helps in overcoming many problems of soil and groundwater pollution due to the small amount used.

**CONTROLLING THE RELEASE OF NANOFERTILIZERS**

Applying chemical fertilizers in an excessive amount can also cause some dangerous things like polluting the soil and water. As a result, many kinds of agrochemical nanofertilizers have been formulated carrying unique features like high effective concentration; enhanced solubility in water medium; controlled release based on response to specific stimuli, reduced environmental impact, and easy nutrient delivery, thus avoiding frequent fertilizer additions (Mikkelsen, 2018). Due to the small nano size of fertilizer, nutrients are more available for plants to uptake compared with common fertilizers, which could further improve Fertilizer use Efficiency and also slow release properties for essential nutrients that may be released at a slower rate during anticipated periods when crops utilizing them hence minimizing leaching losses between time of application and uptake (Subramanian *et al.* 2015). An example is the use of nano-

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zeolite, which is loaded with nutrients necessary for plant growth, which dissolve slowly and help in the slow release of nutritional elements for plants (Manikandan & Subramanian, 2016). The use of coatings or Nanocarriers as a means of nutrient delivery has helped in efficient delivery and control of nutrient release at the right time and enhanced the resistance of fertilizers against decomposition in the environment in which they are present in addition to reducing the amount used, this reduced leaching and environmental problems upon the application of nano-fertilizers that resulted in a decrease in the runoff, and toxicity associated with overdose from mineral fertilizer as well as achieving efficient nutrient utilization through controlled release higher solubility delivery subject required large surface area unique targeting size. (Naderi, & Danesh-Shahraki, 2013).

**MECHANISM OF ABSORPTION OF NANO-FERTILIZERS IN PLANTS**

Nanoparticles can go into plant cells directly through the cell wall if they are smaller than the size of a pore in a cell wall, which usually ranges between (5-20 nm). The passage of nanoparticles that carry nutrients through the cell membrane as well as interactions in the cytoplasm is considered a complex matter, however, scientists would not eliminate this method as one of the basic mechanisms through which the plant root system can absorb nutrients after dissolving the nanoparticles in the soil solution (Mastronardi *et al.* 2015). The nanoparticles may dissolve in the soil solution and provide nutrients as soluble ions to be absorbed by plants, which is similar to what happens with conventional fertilizers, however, nanoparticle solubility rate and amount coming into the soil solution were higher than for traditional compounds because of their small size (in nm range) that enlarges surface area. Nagula *et al.* (2016) explain some factors are responsible that play a vital role in the absorption and transport of nano nutrients into plant tissues.:

1. Types of plants .
2. Plant growth stage.
3. Fertilizer size at the nanoscale.
4. Environmental conditions.
5. Stability of nano fertilizers.
6. Physical and chemical properties of nanoparticles.

**NANO-FERTILIZERS FOR ENHANCING FERTILIZER USE EFFICIENCY.**

Fertilizer use efficiency is defined as the ratio of the increase in the amount absorbed to the amount of fertilizer applied. Fertilizer productivity represents the increase in production as a result of fertilization (Ali & Al-Juthery 2017). An increase in fertilizer use efficiency is one of the main issues and big challenges that face the fertilizer industry and the agricultural sector in general, as well as The fertilizer Use Efficiency now the value is still very low ranging between (40-50% For N, 25 –20% To P&35–40%for K, and 2 -5 % to Zn, Fe, Cu), So if any increase in this values will lead to great reduction for plant needs from essential nutrient, in addition to the economic benefits and reduced the risks of environmental pollution (Sohair *et al.* 2018). Nanotechnology has provided new applications and solutions to these problems, as nano fertilizers have helped to improve fertilizer use efficiency due to its small size and high surface area, this facilitates the penetration of nanoparticles into the plant, whether it is leaves or soil application, as well as the slow release of nano fertilizers that helped plants to Absorption of most nutrients, which achieves maximum fertilizer use efficiency. Nano-fertilizers manufactured using nanotechnology, with a size of 1-100 nanometers, have a large surface area and can hold many nutrients while releasing them slowly and steadily enabling the uptake of required crop-specific nutrient amounts leading potentially to enhanced fertilizer use efficiency (Kumar & Pandey 2014). Fertilizer use efficiency is a prominent indicator in assessing the advances made toward nutrient management improvements. For example, urea is the most widely used nitrogen fertilizer as a source of N available for plant growth; on one hand, urea is exposed to losses as a result of leaching and volatilization, which leads to reduced nitrogen efficiency. the application of nano-fertilizers has reduced the amount of nitrogen lost during crop production and increased the fertilizer use efficiency from 30% to more than 80% (Kaushik, 2016). Several studies have revealed significant improvement in the overall nutrient use

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efficiency of plants post-application of nano-fertilizers (Tarafdar *et al.* 2015). Applying nano-zeolites with nitrogen fertilizer resulted in a controlled release of nitrogen with an increased nitrogen use efficiency in maize plants. The slowly releasing nitrogen sustained to provide adequate amounts for crop daily requirements, without environmental risks like when traditional was adopted (Manikandan, 2014). Also, the foliar application of nano-fertilizer to wheat increased significantly the absorption efficiency of NPK nutrients by plants than to common fertilizers (Jhanzab *et al.* 2015). Appling nano-nitrogen fertilizers were optimal for nitrogen release and provided nitrogen for 60 days to the plant compared to the conventional nitrogen fertilizer for only 30 days, also the effect of nano-fertilizer on plant nutrients absorption was significant, as it showed a higher use efficiency 22% compared to the treatment of conventional fertilizer (Ditta & Arshad, 2016).

**IMPACT OF NANO-FERTILIZERS ON CROP YIELD**

Several research studies reported that using nano-fertilizers highly improved plant yield compared to treatment without using nanoparticles in fertilization. The nano-fertilizer contributed to increasing the surface area, and thus increased nutrients in plant tissue that helps achieve an obvious increase in all yield characteristics as well as quality parameters of crop like protein percentage or oil content and sugar through upgrading rate of photosynthesis and promote growth its parts, this lead for accumulation increment of dry weight then transferring it into the economical part. The main findings in these studies are highlighted below; they observed that the incorporation of nano-fertilizers has resulted mounting a significantly higher level of yield rate per plant than without application to nano-fertilizers treated plants. It was observed, that applying nanofertilizers on maize and wheat increased production because slowly releasing sustained provided adequate amounts of nutrients for crop requirements (Subbarao *et al.* 2013). The application of nano-iron fertilizer in the wheat plants increased the number of branches and number of seeds per spikes−1 as well grain yield and biological yields with a further increase to weight 1000 grains (Harsini *et al.* 2014). The use of silver nanoparticles increased most of the growth and yield characteristics, which indicates that the use of silver nanoparticles has a stimulatory effect on wheat growth and development (Jhanzab *et al.* 2015). Zinc nano-chelates administration applications as maize yield increased comparison with conventional fertilizers of zinc on different characteristics such as number of grains per row, 100 grains weight, grain yield, and harvest index (Janmohammadi *et al.* 2016). The effects of these chitosan nanoparticles loaded with N, P, and K were quantitatively much more than that of conventional chemical fertilizers in terms of grain yield when applied to wheat plants according to the study (Abdel-Aziz *et al.* 2016).). Significantly high responses were also shown using NPK and Super Micro Plus (SMP) fertilizers manufactured using nanotechnology in wheat plants, as compared to common fertilizers (Al-Juthery *et al.* 2018).

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