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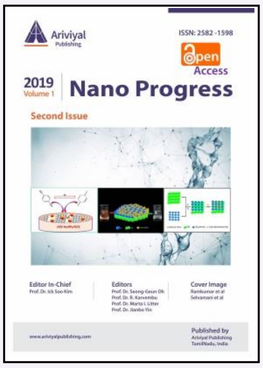

A Review on Nanomaterials as Fertilizer in Agricultural Sector and its Analysis

Gohel Smeetraj,[a] Bhatt Tejas[a] and J. H. Markna*[a]

[a]*Department of Nanotechnology, V.V.P. Engineering College, Rajkot – 360005, India.*

***Corresponding author E-mail address**: jaysukh28@gmail.com (J.H. Markna)

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Abstract: Rapid development of nanotechnology has been promoting the transformation of traditional agriculture, more precisely the invention of nano-pesticides, and nano-fertilizers. Numerous methods and nanomaterials have been developed for agricultural sector such as proper crop growths, crop protection, taking care of seasonal crops, and monitoring the environmental conditions. Utilization of nanomaterials can prompt fine cultivating, which fundamentally improves precision farming efficiency. In this article, analysis of nanomaterials will be reviewed up, and promising capacities. Review aims to explore the nanomaterials which are appropriate for precision farming. We conclude that nanotechnology offers wide opportunities, by providing a sustainable alternative in the agriculture.

Keywords: Nanoparticles; Nanomaterials; Nano-fertilizer; Agriculture; Sustainability

1. Introduction

A natural question arises when scientists and engineers began to use nanoparticles or nanomaterials:[1] “Why they are so interesting? "Why they are so fascinating? Why is the research is going so interesting on these tiny substances, and why should they be tested for processing and inclusion?" Nanomaterials are the collection of atoms.[2] the range varies from 1–100nm. Compared with mass materials, it can fundamentally adjust its physical and chemical properties.[3] Under the natural framework, nano-fertilizers occupy a large part of various metabolic cycles, such as sugar, lipid, nucleic acid, and protein union and their degradation. Precision agriculture makes agricultural operations more rational by reducing waste and energy benefits.[4]

The advent of nanotechnology has led to the inclusion of nanomaterials in many consumer products and industrial applications, including agriculture and food. However, due to the small size and increased surface area of nanomaterials, they are highly reactive, which leads to unexpected concerns, the environmental impact of biological systems exposed to nanomaterials. To clarify its nature and scope the impact of nanomaterials on the biological environment is undergoing extensive research on its role in plants and related microorganisms.[5] Historically, these studies mainly focused on the toxicity of nanomaterials.[6,7] They are usually designed with high doses and short exposure times.[8] In contrast, there are relatively few studies in the mainstream bio-nano science literature that prove the beneficial effects of nanomaterials in plants. As literature shows that these trends lead to nanomaterials themselves have the concept of toxicity.[9] Recently, in the context of fertilizers, people have become interested in nanomaterials of nutrient elements, so the term "nano fertilizer" has been used.[10,11] Current conventional fertilizers have low nutrient absorption efficiency and are accompanied by high losses and accompanying negative environmental consequences. The use of nano fertilizers has the potential to reduce the loss of nutrients in fertilizers and may reduce the number of fertilizers applied. As seen in the literature point of view, compared with nano packaging, nutrient loss, especially the loss of nitrogen and phosphorus is reduced to the conventional form, therefore, nanotechnology can be used to solve the environmental impact of traditional fertilizers.[12]

The concept of nano-fertilizers conceptually involves the stakeholders of fertilizers (industry, researchers, farmers, and the government).[13] From the large-scale production and use of mineral nutrients to nano-scale production, investment and practice have taken a big step, raised concerns about nanoparticle size, process scale-up, and field application strategy. However, studies evaluating nutrient use nanomaterials as fertilizers have been biased towards micronutrients, mainly zinc, copper, manganese, and iron.[14,15] Furthermore, the need for trace elements, plants need macronutrients (nitrogen, phosphorus, and potassium, and to lesser extent calcium, sulfur, and magnesium) in the soil.[16] Fertilizers produced by the fertilizer industry contain a large amount of these nutrients. Therefore, the basic research speed surprising that importance in crop production, development (R&D) involving macronutrients has not yet been carried out.

Table 1. Nano-fertilizer products which are approved and manufacture in India

Company Name	Fertilizer Name	Specification	Country of Origin
IFFCO	IFFCO Nano Biotechnology Research Centre (NBRC)	Nano Nitrogen, Nano Zinc, Nano Copper	INDIA
Geetharam Agencies, Sole Proprietorship (Individual)	Tropical nano PHOS	Nano Phosphorous	INDIA
Geolife Nano Fertilizer Combi	Geolife Nano Fertilizer Combi	Zn + Mn + Cu + Fe + Mg 16.6+3.8+3.8 %. It is a combination of all the Micronutrient required to plants increases the crop yield by correcting micronutrient deficiency and ensuring better nutrient balance & plays a major role in structure and functioning of cell walls	INDIA
TSR Organic fertilizers	TSR Organic fertilizers	Flower Booster 100% Organic Nano Technology Product	INDIA
Fulgro Nano Plant - Organic Liquid vermicompost Fertilizer	Fulgro Nano Plant	Suitable for all types of living plants, regardless of climate and geological conditions	INDIA
Geolife NPK	Geolife NPK 19-19-19 Water Soluble Fertilizer,Nano fert	npk 19 19 19 fertilizers for plants	INDIA
Infinite Biotech	Infinite Biotech	Booster Bio-Nano Plant Growth Promoter	INDIA
P-Magic Gold	P-Magic Gold 5gm Plant Growth Regulator (PGR) Nano Technology Based Product (100% Organic)	Decreases upto 50% cost of Fertilizers	INDIA
Magic Root 4the Generation Nano Plant Growth Promoter	Magic Root 4the Generation	It increases the content of chlorophyll, protein, nucleic acid in the plant and thus accelerates photosynthesis	INDIA

Scientific basis to support the development and industrialization of nano-fertilizers take off and highlight some outstanding issues related to industrial production and the use of nano-scale nutrients as fertilizers.[17] In this review, the terms "nanomaterial", and "nanoparticle" are used interchangeably, regardless of their subtle meaning in the nanoscience and nanotechnology literature. These terms refer specifically to nanoforms of crop nutrient elements,[18] with carbon, silver (Ag), silver, titanium oxide (TiO_2), cerium oxide (CeO_2), aluminum (Al), as with other nanomaterials such as (N, P, K, S, Ca, Mg, Mn, Cu, B, Zn, Fe, Ni, Mo), they are usually not part of conventional crop fertilizers, but despite this, they have been extensively evaluated on plants and sometimes yielded positive results. Similarly, since the soil is the main growth medium for most crops, discussions about the benefits of nanomaterials will focus on the work done in the soil system, and only briefly mention the work in growth media.

Four subjects will be managed that could advise how the business might react to the possibility of nanofertilizers going ahead:

1. The "harmful" categorization given to nanomaterials
2. Proof of nanofertilizer agronomic advantages
3. Fabrication of successful nanofertilizers and more secure field application techniques
4. The requirement for a cost−benefit examination of nanofertilizers.

2. Nano-fertilizer Products:

Although there is a lot of evidence that the wise use of nano-level nutrients can be used as fertilizer, it seems that the global large fertilizer industry entities have not yet the research and development results have made people excited about investing in nano-fertilizers.[8-19] It is worth noting that according to reports, most nanomaterials evaluated as “nano-fertilizers” on crops are either commercial products sold by chemical companies for non-crop fertilization purposes, or they are produced internally, measured in milligrams per gram. So use them for large-scale agriculture is still impossible. However, some countries seem to be advancing the idea of nano-fertilizers. Table 1 lists the hypothetical nano-fertilizer products approved for import into the country. As can be seen from this table, the companies in question are not among the key global fertilizer industry enterprises such as IFFCO, Geetharam Agencies, Sole Proprietorship (Individual), Geolife Nano Fertilizer Combi, TSR Organic fertilizers, Fulgro Nano Plant - Organic Liquid Vermicompost Fertilizer, Geolife NPK, Infinite Biotech, P-Magic Gold, and Magic Root 4the Generation Nano Plant Growth Promoter. Therefore, unless such a small company is a subsidiary of a large company, not sure about their current visibility level and the scale of production will affect the development of global nano-fertilizers. Therefore, unless such a small company is a subsidiary of a large company, not sure about their current visibility level and the scale of production will affect the development of global nano-fertilizers. Regarding the number of products, most of the listed products are below 1 kg, Nano-fertilizer, except for the "nano" label in its name, the product seems to be just a "mixture" of various conventional nutrients and other additives (such as chelating agents), EDTA. Agri industries did not provide clear information about what the product is made into "nano" (i.e. size) or the type of nano product (i.e. whether it is the original nano, surface modified nano, composite material nano or bulk fertilizer with nano function). To be fair, given the nature of nanomaterials, a specific set of quality assessment standards must be developed and used to validate nano fertilizers, in addition, need for chemical quality (concentration and, purity) assessment suitable for all types of fertilizers. Some more obvious considerations particularly relevant to the certification of nano-fertilizers include (i) Characterization data, (ii) Size to evaluate whether they are really nanometers (100 nanometers or smaller), aggregates of nano or bulk (size> 100 nm) materials disappear in nano form, (iii) Stability to assess its integrity nano-level product or conversion rate before and after interaction with soil and crops, (iv) Shape affects dissolution rate and may affect biological activity,[20] and (v) Functionalized or combined to check whether they are surface modified or mixed products. In addition, to concentrate these parameters require a set of analytical instruments has nano-level sensitivity that has generally not suitable for batches material.

3. Are Nanoscale Micronutrients inherently toxic or is it a matter of how and where they are used?

The production of most crops in the world is based on the soil production system, using the recommended dosage of nutrients probably consistent with the physiological characteristics of crops need or soil nutrient level. However, as selected recent comments,[6-21,22] extensive research in plant nanoscience including experiments conducted in artificial media, such as nutrient solution, agar, sand, or other non-soil media design with nanomaterials are benefits to the entire growth cycle of crops; or as literature involves nano-level nutrients elements such as Ag, Ti, Ce, Al, and Cd, among which they are known to be highly toxic. In particular, non-soil media will the effect on material behavior is different from that of agricultural soil considering the various chemical, physical and biological complexities that nanomaterials face in the soil; except in a few cases artificially introduction, non-soil media research has been lacking the existence of microorganisms, and microorganisms are a constant the biological properties of soil can affect nanomaterials behavior and activity.[23]

The focus of plant nanoscience research is toxicology involves exposure of plants to high doses of nanomaterials, especially micronutrients, have a short duration two impressions are produced in non-soil media: "nanoscale" implies "toxicity", and all nanomaterials have nano-specific toxicity, which is always greater than its volume, ionicity or equivalent. However, it has always toxic stories of nutrients? nanomaterials are all nutritional materials. Moreover, these materials really more toxic than traditional materials? Looking at the evidence shows that these considering most nano-study that conducted these conclusions under conditions separated from the actual soil-plant system so, the complete story will respond to nanomaterial exposure in actual agriculture set up. The toxicity of nanomaterials is it depends on the context of soil. The default result of nanomaterials-plant interaction is not toxic. Plants respond to them differently, depending on the specific nanomaterial, this research matrix (a type of environment), exposure dose and time, and targeted plants.[24] In fact, when viewed as fertilizer and with proper dosage and deployment in the soil, it has a toxic effect often denied, replaced by indifference (No effect) or the opposite result (beneficial), may be inconsistent with the effects observed with conventional fertilizers different soils.

In any case, the wise use of nano-scale materials is essential to maximize returns while minimizing risks, aware of the influence of specific factors (such as pH), inorganic and organic ingredients, and microorganisms it helps to optimize nano-fertilizer to realize its benefits. Hope the ongoing research on several micronutrient nano-fertilizers, including Connecticut Agricultural Experiment Station and University, for example, El Paso of Texas[25] and other places in the UK, iron-based nanoparticles and Potatoes[26] will produce positive results, thereby further the prospect of nano-fertilizers.

4. Is Research convincing About the Benefits of Macronutrients as Nano-fertilizer?

According to reports, especially for nitrogen, it is used as a "nanourea" benefiting several crops in recent reviews for China[27] including rice, radish, celery, cabbage, eggplant, pepper, tomato, and others. In the case of rice, nano-urea increases significantly grain yield and nitrogen uptake, resulting in reduced nitrogen loss compared with conventional urea, it is as high as 74%. However, with for micronutrients, little is known about the mechanism of nano-scale macronutrient fertilizers. The available evidence shows the nano-enablement of nitrogen and phosphorus fertilizers either act in the rhizosphere to regulate the release of active substances nutrients or promote the intake of complete nutrients fertilizer material.[28–36] Therefore, this gap raises the following questions: is the current level of research on nano-fertilizers enough to make fertilizers beyond the interest industry? This part of the research involving N, P, K and S, Mg (if any), and Ca highlight significant nano-enabling of N includes Urea or other N sources with nano-sized hydroxyapatite (ureaHAP), using nano-clay and other polymers, and reducing N salt. In general, these have greatly reduced the rate of nitrogen release and the associated nitrogen loss shows that, in contrast, the efficiency of the use of N in nano-forms has been improved to regular form. Therefore, they represent both agronomies and participating in the industry’s environmental management motivation to produce N nano fertilizer.

Nano P can chemically form i.e. sufficiently alkaline to precipitation, the gradual reaction of calcium hydroxide or calcium chloride, and phosphoric acid; however, sodium phosphate (Na_2HPO_4) can be used instead of phosphoric acid. Stabilizers, such as carboxymethyl cellulose (CMC) or Cetyl (hexadecyl) trimethylammonium bromide (CTAB) can be added to prevent particles from gathering in the suspension. The resulting product, nano-scale precipitate, nano-hydroxyapatite (NHAP), which is also some synthetic mineral-rich in P and Ca natural. However, Nano P can also pass the grind massive phosphate rock (PR) to the nanometer level. From the environment point of view, phosphorus storage in the soil is a subject of high concern intensive agriculture, in which phosphate fertilizers are used as extensively amount. In the case of excess phosphorus, the agricultural environment usually has no reports on: toxicity and reduced productivity of target crops. But its role, especially for fertilizers with higher soluble phosphorus such as triple/single phosphate (T/SSP) eutrophication and loss of water species. From this negative environmental impact, the main benefits of using nano P or nHAP nano-phosphate fertilizer compared with the traditional soluble P fertilizer, nano-PR reduces the soil’s solubility and fluidity, therefore, the risk of eutrophication[32] is reduced and the likelihood is reduced plants that absorb whole particles of P.[33] These benefits are, of course, in addition to having a more obvious impact on crops development and productivity. Although found with Phyto-availability, absorption rate, and agronomical effects of phosphorus the soluble phosphate fertilizer has not been finalized and contradictory.[37,38] It can still be considered that the current overall data may be sufficient to ensure that stakeholders all the effects of nano-phosphate fertilizer agricultural productivity, improved environmental management, the relative production cost compared with other phosphate fertilizers. If the effect of nano-phosphorus is not ideal due to soil type,[38] then can be used by a mixed product of nHAP and nano calcium sulfate (nano-CS), it has been shown that it can further reduce the mobility of P.[37] This is in addition to Ca and S in nano CS supplement crop nutrition.

Compared with N and P, the specific involve other macronutrients (ie K, S, Ca and There is almost no magnesium, but the available data[39–43] show nanoparticles based on K, S, Ca or Mg as fertilizer, although more soil-based research is needed to further clarify the relationship between these nano-nutrients and their conventional equivalents in complex agricultural environments. Although the study lacks a comparison with conventional magnesium because of the impact on crop productivity, it provides potentially useful information on the importance of using magnesium early as a pesticide, considering whether plants are protected, resists the withering of bacteria depends on whether they are the first exposure to nanomaterials or pathogens. So, it is well studied by Imada et al.[43] and it is notable.

5. Nano-fertilizer: To produce and how safely and efficiently apply them?

Production of nanomaterials derived from mineral nutrition use different chemical synthesis methods, especially wet methods, specific examples include sol-gel, hydrothermal, uniform precipitation, template synthesis and reverse micelle method.[44] However, there are productions based on the green synthesis, involving the use of plants or microbial extracts containing enzymes and reducing agents to reduce salt to nano-element form. The method involves physically grind or grind bulk materials to nanometer size. The detailed description of these methods is out of the scope this research, but nanomaterials can be from almost any one or more of all mineral nutrients method. But the question is which method is most effective is it suitable for industrial scale-up? About green synthesis, crops or microorganisms must first be cultivated and process its extract before using it in nanoparticles synthesis, which increases cost and time, so it’s unlikely ways of the fertilizer industry. For physical methods, milling block minerals mined at the nanometer level, such as phosphate rock, potash feldspar, carbonate and other minerals may produce large amounts added to the right amount of nano fertilizer in a reasonable time proper characterization of the final product to meet the minimum requirements of qualification criteria. However, nano-milling can in addition to the potential energy demand. The demand for energy also highly causes personal and environmental hazards the nanoparticles are suspended in the air during the grinding process. Therefore, grinding there are fewer and fewer bulk products producing nanomaterials there are reports in the literature these days.[44] On the other hand, from large the current method can be directly used for large-scale the reactor can produce a large amount of nano fertilizer in a short time a period of time. These challenges are therefore essential to invest in analytical capabilities to produce stable Nano fertilizers with specific functions.

6. Analysis of Nano-fertilizer

Coupled with the agronomic benefits of nano-fertilizers, production cost and other related constraints, as well as availability and ability to bear farmers is an important factor that may arise play a role in persuading the industry to invest in nano-fertilizers produce. When cost is not more than existing fertilizer with nano-fertilizers; when Nano-fertilizers are so effective that they reduce fertilizer application rate or annual demand or when the traditional negative environmental impact fertilizers need to be resolved by regulations. Some are signs of the economic possibilities of nano-fertilizers proposed by nanotechnology experts dedicated to improving fertilizers, as reported by popular and professional news media "The Economist"[45] and the American Chemical Society Chemistry and Engineering News.[46] However, despite the hope nano-fertilizers are still an important and important part it is an analysis of its costs and benefits. From an industry point of view, economic analysis is needed to compare nanomaterial synthesis methods that are cheaper and more sustainable for the nano-fertilizer; it has a high production turnover rate. In the case of nanofertilizer production there are several constraints associated with first based suitable synthesis technique i) in the vicinity of mass production ii) amount of added nanomaterial in a fertilizer iii) based on above two points final price of nano-fertilizer is confusing. Yet the nano-fertilizer for field applications and these materials must be used globally tons per unit time in the industry the current gram to kilogram level is often reported in the literature.[45,46]

All basic research shows there is not enough detailed information on the agronomic benefit of nano-fertilizers the economic sense of using them. Adhikari's research[36] points out that overall corn yields are low (1-10% less) Nano PR (namely nano-level phosphate rock) ratio regular P (SSP) depends on the source of PR. But they are also pointed out that for farmers, production costs are lower Nano-PR and its residual effect in subsequent planting are better, will eventually offset immediate gains obtained through SSP. However, there is no actual proof of any residual impact on subsequent crops to show the cost-saving effect. Similarly, Delfani et al[42] reported that yield of pea beans increases 63% to 82% on application of nano-iron fertilizer as compare to conventional iron fertilizer 0.5g/kg notable points that production cost for 1kg of nano-iron is 800 USD. Unfortunately, the author did not provide similar works information on the cost of conventional iron they used to allow cost-benefit comparative analysis. The yields which describes increased by 24% and 52% respectively, when processing eggplant with conventional and nano CuO fertilizer, including the cost of a 25g bottle of regular CuO the price in the US is US$18.50, and the price of nano CuO is $44. This yield difference per acre translates to US$4637 CuO nano fertilizer investment 26 USD (44 USD – $18.50). As can be seen from the above, not in all cases nano-fertilizers can produce better results compared with the traditional fertilizer or appropriate but there is no manufacturing at all. Therefore, there is no benefit comprehensive economic analysis of Nano-fertilizer will provide useful information compared to the traditional fertilizers industry's expected investment in nano-fertilizers same as farmers.

7. Ideas and prospective; Industrial interest in Nano-fertilizer

The previous description shows that nano-level nutrients are by default, its toxicity is not higher than its micron or ion level peers, using them can benefit crops wisely. Therefore, take full advantage of the benefits of nanoscale nutritional elements need to attract the attention of the industry to introduce nanotechnology into fertilizer solutions. To this end, Nano-fertilizer researchers need to evaluate what the fertilizer industry needs and how their current research methods fit these needs. When doing so, they should deal with nano-fertilizer as fertilizers, all assessments of their impact on crops similar to conventional fertilizer: Application rate related to crop and soil requirements; judgment strictly based on effects derived from research conducted during growth the most suitable substrate for the crop being evaluated; contains related control in experimental design (conventional); Research and use suitable nano fertilizer strategy; and let the experimental crops fully mature. In addition, the following methods should be used for nano-fertilizer evaluation: Nano-nutrient blend mimics traditional fertilizer usually involving multiple nutritional applications simultaneous application (for example, NPK). The concept of balanced crop nutrition is very relevant suitable for agricultural areas with poor soil in the world the crop does not respond to the application of a single nutrient, and places rich in many nutrients. The most important is, the research and development of nano-fertilizers should pay more attention to macronutrients, especially NPK, and NPK is the fertilizer industry.

At the same time, research and development scientists of agricultural should not only prototype of effective nano-fertilizer, but also developed ideas and concepts that can be sold to the process amplification industry. Realized the need for enhanced use of the efficiency of existing macronutrient fertilizers, research and development work has led to products with specific characteristics, such as slow release and trigger the release of fertilizer, now all zoomed up. Fortunately, nanomaterials have unique properties that allow them to be functionalized in multiple ways. These characteristics, it is now being used to produce effective nanomaterials for other industries. Nanomaterials need similar efforts intended to be used as fertilizer, so advanced nano-fertilizer from most of the original products that are easily manipulated products with more features in the test environment. to this end, improvements in nano-nutrient production so far improved nano fertilizers include those already in the previous part involved surface modification, such as alginate and chitosan.[47,48] Use the creatures or the potential of creature's non-biological materials, such as lignin, aminopropyltriethoxysilane, clay is also mentioned in the nano-fertilizer design.[49,51] In addition, the proven possibility of producing macronutrient nanofertilizers (such as nano-N, nHAP or urea-nHAP) provides a strong premise for the production of nano-scale macronutrients fertilizers should be attractive to the industry.

Recently, Monreal et al[52] describes the ongoing bio-nanotechnology technologies that can improve nutrient utilization efficiency the basis for real-time molecular recognition between nanonutrients and root exudates. Similarly, nanocomposites can be assumed to respond to soil types for example, pH-sensitive surface properties allow response in acidic or alkaline soils. Also,

Fig. 1. Bulk Fertilizer Production Line

development with nanometer Zn, B, Fe, Cu, or other micronutrients can be used not only to improve the utilization efficiency of certain macronutrients formula but also helps to absorb the necessary micronutrients enter the plant and help improve grains or nutritional quality of vegetables for human consumption. Can imagine Nano-scale micronutrient NPK can be produced online use aerosol or colloidal spray technology, where a large amount of NPK fertilizer is used by spraying or mixing with nano fertilizer, coating the surface of the final product before exiting the production line. This online process that takes place downstream of production will be an additional technology; will not cause any interference to the upstream fertilizer production process.

Fig. 1 Simplified illustration of nanoscale mass production fertilizer (NPK in this case). NPK fertilizer occurs upstream, functionalizes finished fertilizers separately able to pass spray or mix NPK and nanoparticles in-line, downstream.

Simplified diagram of this concept as the picture shows Fig. 1. NPK with micronutrient nano-function is a ready-to-use, all-in-one product, there may be more expensive than traditional, but better than apply nitrogen, phosphorus, potassium and micronutrients separately. However increased yield, improved product quality and plant health increased value-added expectations must be offset additional input costs for farmers.

The nano-fertilizer as in Fig. 1, some research groups have also participated in the synthesis of micronutrient nanoparticles, nanoaerosol technology and the development of crops. The International Fertilizer Development Center (IFDC) has cover NPK with micronutrients. Therefore, macronutrient fertilizer with micronutrient nanoparticles as long as there is proper cooperation and industry, it can be achieved partnerships. Incorporating nutrient nanoparticles Bulk fertilizer can solve some problems related to the stability of nanoparticles and how to best apply they are in large-scale field operations. First, the potential phase separation, premature conversion into non-nano substances, Nano-drift can be reduced by Nano-fertilizer is used as the physical component of bulk fertilizer.

Use any pesticide, no matter it is nano-pesticide or conventional pesticide, related to environmental risks. Obviously, Nanotechnology has begun to assume Biotechnology, resistance from society or unwillingness to accept technology driven by risk perception. Kah et al[53] discuss how some agrochemical industry participants stay away from the prefix "nano", maybe it can explain why so far, no clear nano-agrochemicals have appeared big player. Admittedly, the negative effects of nanomaterials handle it seriously. But for nano fertilizers, not based on context (nutrients or Ag nanomaterials, applied dose, the substrate used, exposure time, etc.) to any avail and may prevent you from moving towards development and application of nano-fertilizers. In contrast, evidence-based concern, criticism, and distinction we have nutritional nanomaterials from other nanomaterials trying to do it here will help guide development and accept nano fertilizer. In this regard, plant nanoscientists the benefits should continue to be demonstrated and disseminated the use of nano-fertilizers in crops based on smart dosages and the appropriate growth matrix, compared with the existing fertilizers and acceptable application strategies. Other industries are benefiting a lot from the development of nanotechnology.

8. Conclusions

Nanotechnology is very useful in improving the growth, yield and health of crops. It's most important advantage is in the form of nanofertilizers, which account for most of the research in this field. The analysis of nanofertilizers such as N, P, Ca, NPK, Fe and chitosan is disclosed. When sprayed on crops at very low concentrations, these compounds have a direct effect by increasing crop growth, final product and quality. Higher concentrations of these fertilizers may have negative effects and even toxicity. Because nanomaterials enhance the absorption of nutrients by crops, they may be resistant to environmental and biological stress. In above mentioned, it is possible to analyze the basis of the positive effects of these compounds on crop growth and productivity, and to evaluate any negative effects that these compounds may have.

Conflicts of Interest

The authors declare no conflict of interest

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