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Smart Fertilizers and Pesticides VIA Nanotechnology for Agricultural Sustainability

Fawzy ZF[1]* and Wafaa Mohamed Haggag[2]

[1]*Vegetable Research Department, Agricultural and Biological Research Division, National Research Centre, Egypt*

[2]*Plant Pathology Department, Agricultural and Biological Research Division, National Research Centre, Egypt*

*Corresponding author: Fawzy ZF, Vegetable Research Department, Agricultural and Biological Research Division, National Research Centre, Egypt

Abstract

Predicting that in the year of 2050, our planet will inhabit over 9 billion completely trusted people. This will pose serious problems related to food security sector, water availability and energy supplies sector, especially in the least developed countries in worldwide. Given that human pressure on natural resources has already reached critical levels, international agencies such as the Food and Agriculture Organization of the United Nations (FAO) are seeking scientific research to identify innovative solutions to support the core sector. Actually, Nanotechnology is a rapidly developing field with the potential to advance agriculture and the food industry with new tools that promise to increase food production in a sustainable manner and protect crops from pests. These expectations are coupled with some doubts about the fate of nanomaterials in the agricultural environment issue. However, the field application of engineering nanomaterials has not been properly investigated yet, and many aspects have been considered only in theory or with models, making it difficult to properly assess the utility of engineering nanomaterials for plant fertilization, pesticides and protection.

Keywords: Smart Fertilizers; Smart pesticides; Nanotechnology; Agriculture sector

Introduction

Agriculture ineffectively uses traditional inputs (water, energy, land, fertilizers, and pesticides) and a large portion of plant protection products applied annually are lost or not available for target de Rosa [1] and de Oliveira [2]. Furthermore, agriculture (crop cultivation, livestock, and deforestation) is a major contributor to greenhouse gas emissions such as CO2 and Methane that produce about from 22- 24% of the total annual amount emissions worldwide Smith [3]. Production of waste is another issue related to the primary sector. European countries produce about 90 million tons of agricultural waste annually EUROSTAT [4]. The European Commission has recognized nanotechnology as one of the six "major enabling technologies" that contribute to sustainable competitiveness and growth in many areas of industrial applications that support the transition to a greener economy. Before beginning to deepen the analysis of the potential benefits of applying nanoscience to agriculture.

The recent scientific literature indicating promising opportunities for nanoscience and nanotechnology to improve the sustainability of agricultural food sectos [5]. From a quantitative perspective, by examining the growth of scientific literature on nanotechnology, it appears clear that interest in research in the field of nanotechnology has grown significantly between the end of the twentieth century and the beginning of the twenty-first century Nazim & MAhmad [6]. Specific agricultural applications of nanotechnology include , first, delivery systems enabling the release of agricultural chemicals that allow the release of fertilizers, pesticides, and herbicides, second, field sensing systems to monitor environmental pressures and crop conditions and third is improving plant characteristics against environmental stresses and diseases Gogos [7] and Chen & Yada [8].

Smart fertilizer technology in agriculture sector

Indeed, the best management practices for fertilization are those that support the achievement of the main goals of sustainability of agriculture: productivity, profitability and environmental health. One of the main pillars of this vision

is smart fertilization to improvement in crop production Manjunatha [9], and Morales-Díaz [10].Nanotechnology can play an important part and role in promoting agricultural sustainability, after providing the viability of so-called "smart fertilizers". In other words, nanostructures act as a carrier of the nutrients and allow for controlled release.

The design of smart fertilizers strongly affects nutrient release and reduces losses. In field conditions, these products are provided to crops by watering or spraying them on vegetable curtains. By applying nanotechnology in agriculture, smart fertilization will be done in various ways. In particular, nutrients can be managed as follows: They are delivered as particles or emulsions with nanoscale dimensions: a research body is being developed that aims to clarify whether nanoparticles (such as fullerenes, carbon nanotubes, nTiO2 and nSiO2) at different stages of crop growth may or may not replace traditional fertilizer practices in part Millan [11]. Ironically, due to leakage and volatilization, nitrogen fertilizers are more harmful to the environment. In the search for sustainable fertilizers, nanotechnology has received recent attention.

Nanotechnology strives to take advantage of unique and beneficial properties in materials with sizes less than 100 nanometers. Among the many reports trying to herald a nano-solution to produce more effective fertilizer, work on encapsulating urea-hydroxyl apatite nanoparticles in small cavities nano-porosities present in a woody matrix, Glyricidia sepium and montmorillonite clay appears to lead to an effective and sustainable slow release of Plant nutrients in the soil. Slow release "Smart fertilizers via nanotechnology": The capsule slowly releases its load over a longer period of time to synchronize plant absorption and reduce leaching. Quick release: The capsule casing is broken when touching the paper surface.

Specific release: nutrient release occurs through the mechanism of recognition between the receptor (molecule or functional group) associated with the cortex and the target molecule. Moisture release: The crust breaks down and releases nutrients in the presence of water. pH release: The shell dissolves only in a specific alkaline / acidic environment Magnetic / ultrasound pulses: The shell opens in response to a magnetic or ultrasound pulse emitted by a human-controlled system (micro-cultivation). With regard to the efficacy of nanofertilizers "produce smart fertilization", it must be said that the potential for applying Nano fertilizers has not been extensively studied yet. However, some successful examples have shown that these new formulations significantly improve fertility efficacy Nayyar , Ezz El-Din, Prasad , Mufamadi and Sekhejane[12-15].

The research challenge is to develop and test carrier vectors that allow release of nitrogen control, according to a schedule that may coincide with the physiological needs of crops. Actually, we are still at a stage where studies on interactions between nanomaterial and organisms provide conflicting results. This also occurs for studies on Nano fertilizers. Nanotechnology has attracted the attention of scientists because of its ability to increase the efficiency of nitrogen use and contribute to sustainable agriculture. Numerous recent reports have examined nanotechnology in agriculture, especially in the fields of precision agriculture, nanoscale sensors and food packaging Sekhon [16]. However, there was a dearth of discussions about fertilizers. Most importantly, the roots and leaves of the plant contain nano-micro pores. Thus, nanomaterials with small dimensions and large areas can increase interaction with plant surfaces, thereby improving nutrient absorption. Recent reports that penetrate carbon nanotubes, tomato seeds Khodakovskaya [17] and nanoparticles of zinc oxide that enter the grass root tissue Lin and Xing have shown the opportunity to use methods of delivery using the nanoparticles of plant surfaces.

Nanoscale fertilizers can deliver nutrients to crops in one of three modes: “Nutrients can be encapsulated within nanomaterials such as nanotubes or nanomaterial, coated with a polymer protective layer, or delivered in the form of molecules or emulsions of nanoscale dimensions” De Rosa. In the end, the ratio of the high surface area to volume will be a boon for the nanofertilizer that improves the performance of even the traditional promoted Polymer-Coated Slow Fertilizers that have been innovatively stable over the past decade.

Smart pesticides technology in agriculture sector

Chemical pesticides are mightily used to improve agriculture production and quality. However, chemical pesticides are unsuitable due to increase hazards for human health and environment. Nanotechnology has great potential to protect plants from diseases ,virus, pests ,weeds , diagnose of plant diseases , improve food yield and quality [18,19]. Nanoencapsulated pesticides can supply controlled release kinetics and improving solubility, permeability, stability, and efficiency [20,21]. The utilization of nanotechnology to originate novel pesticide formulations has shown great possibility for providing environmentally safer alternatives. Smart nanopesticides are intended to efficiently delivery enough amounts of effective ingredients in restraint to biotic and or abiotic stressors and potential to be used in agriculture [22]. Theutilize of smart nanopesticides is a hopeful technology that is still in an early

phase of development and needs further development to provide and supply its use in agriculture industry. The future trends of nano formulations of pesticides is involving nanomaterial and nano emulsions of bio pesticides [21].

The development of nano-carriers pesticide formulation, can be encapsulated with chemical ionic as carbon, silver, gold, silica and alumino-silicate or covalent interactions, or be enclosing in a polymeric mesh [22,23]. Application of bio and or nanoparticles in plant disease control is an attractive way that may show very efficient in future [22,23]. Bio-nanoparticles of silicon and titanium were widely biologically synthesized from different biological agents of bacterial and fungal isolates against wheat powdery mildew [24]. Application of silver nanoparticles on cucurbits under field condition caused greater fungal disease suppression [25]. Nanoparticle also has been development for viral diagnostics which help to discover the virus strain by identify proteins and DNA in diseases and healthy and diseased to management disease. The weed management using nanoherbicides is considered as an alternative to the chemical herbicides and in hormonal waste-water treatment [26]. The activities of insecticidal silver nanoparticles against Aphis nerii has also been recorded [27,28].

Conclusion

In conclusion, the use of nanomaterials in agriculture still requires deep basic knowledge about the fate of nanomaterials in the agricultural environment. However, the most mature, and at the same time, one of the most promising aspects of the interactions between agriculture and nanotechnology is that of waste valuation. Therefore, it is appropriate to repeat once again that nanotechnologies are in turbulent development. This means that applications currently being developed will soon be overlooked with other ideas that will solve other issues in the field of sustainable agriculture. This principle is only the driving force for developing knowledge and promoting technological applications.

References

1. De Rosa MC, Monreal C, Schnitzer M, Walsh R, Sultan Y (2010) Nanotechnology in fertilizers. Nature Nanotechnology 5: 91.
2. De Oliveira JL, Campos EV, Bakshi M, Abhilash PC, Fraceto LF (2014) Application of nanotechnology for the encapsulation of botanical insecticides for sustainable agriculture: Prospects and promises. Biotechnology Advances 32: 1550-1561.
3. Smith P, Bustamante M, Ahammad H, Clark H, Dong H, et al. (2014) Agriculture, forestry and other land use (AFOLU). In: Edenhofer O, Pichs-Madruga R, Sokona Y (Eds.), Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, Cambridge University Press, USA, pp. 811-922.
4. EUROSTAT (2017) Total waste generation in the EU-27 by economic activity in 2008.
5. Kagan CR (2016) At the nexus of food security and safety: Opportunities for nanoscience and nanotechnology. ACS Nano 10: 2985-2986.
6. Nazim M, Ahmad M (2008) A bibliometric analysis on nanotechnology research. Annals of Library and Information Studies. New Visions in Plant Science 55: 292-299.
7. Gogos A, Knauer K, Bucheli TD (2012) Nanomaterials in plant protection and fertilization: Current state, foreseen applications, and research priorities. Journal of Agriculture and Food Chemistry 60: 9781-9792.
8. Chen H, Yada R (2011) Nanotechnologies in agriculture: New tools for sustainable development. Trends in Food Science & Technology 22: 585-594.
9. Manjunatha SB, Biradar DP, Aladakatti YR (2016) Nanotechnology and its applications in agriculture: A review. Journal Farm Science 29: 1-13.
10. Morales-Díaz AB, Ortega-Ortíz H, Juárez-Maldonado A, Cadenas-Pliego G, González- Morales S, et al. (2017) Application of nanoelements in plant nutrition and its impact in ecosystems. Advances in Natural Sciences: Nanoscience and Nanotechnology 8: 1-13.
11. Millan G, Agosto F, Vazquez M (2008) Use of clinoptilolite as a carrier for nitrogen fertilizers in soils of the Pampean regions of Argentina. Ciencia Investigación Agraria 35: 293-302.
12. Nayyar A, Puri V, Le DN (2017) Internet of nano things (IoNT): Next evolutionary step in nanotechnology. Nanoscience and Nanotechnology 7(1): 4-8.
13. Ezz El-Din H, Manjaiah DH (2017) Internet of nano things and industrial internet of things. In: Acharjya D, Geetha M, editors. Internet of Things: Novel Advances and Envisioned Applications. Studies in Big Data. Cham: Springer pp. 109-123.
14. Prasad R, Bhattacharyya A, Nguyen QD (2017) Nanotechnology in sustainable agriculture: Recent developments, challenges, and perspectives. Frontiers in Microbiology 8: 1014.
15. Mufamadi MS, Sekhejane PR (2017) Nanomaterial-based biosensors in agriculture application and accessibility in rural smallholding farms: Food security. In: Prasad R, Kumar M, Kumar V (Eds.). Nanotechnology. Springer, Singapore, pp. 263-278.
16. Sekhon BS (2010) Food nan- otechnology - an overview. Nanotechnology, Science and Applications 3: 1 -15.
17. Khodakovskaya M, Dervishi E, Mahmood M, Xu Y, Li Z, et al. (2009) Carbon nanotubes are able to pene- trate plant seed coat and dramatically affect seed germination and plant growth. ACS Nano 3: 3221-3227.
18. Frewer LJ, Norde W, Fischer ARH, Kampers FWH (2011) Nanotechnology in the agri-food sector: implications for the future. Wiley, Weinheim.
19. Sonkaria S, Ahn SH, Khare V (2012) Nanotechnology and its impact on food and nutrition: a review. Recent Pat Food Nutr Agric 4: 8-18.
20. Kumar S, Nehra M, Dilbaghi N, Marrazza G, Hassan AA, et al. (2019) Nano-based smart pesticide formulations: Emerging opportunities for agriculture. Journal of Controlled Release 294: 131-153.

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DOI: *10.46718/JBGSR.2020.03.000060*

21. Kumara E, Monika Nehraa , Neeraj Dilbaghia , Giovanna Marrazzac, Ashraf Aly Hassane, et al. (2019) Nano-based smart pesticide formulations: Emerging opportunities for agriculture. Journal of Controlled Release 294: 131-153.
22. Haggag WM, Hoballah MME, Ali RR (2018) Applications of Nano Biotechnological Microalgae Product for Improve Wheat Productivity in Semai Aird Areas. International Journal of Agricultural Technology 14(5): 675-692.
23. Haggag Wafaa M (2014) Nanotechnology for plant diseases control. International J Engin Res and Manag 1(5): 244-248.
24. Farhat MG, Haggag WM, Thabet MS, Mosa AA (2018) Efficacy of Silicon and Titanium Nanoparticles Biosynthesis by some Antagonistic Fungi and Bacteria for Controlling Powdery Mildew Disease of Wheat Plants. International Journal of Agricultural Technology 14(5): 661-674.
25. Lamsal K, Sang-Woo K, Jung JH, Kim YS, Kim KU, et al. (2010) Inhibition effects of silver nanoparticles against powdery mildews on cucumber and pumpkin. Microbiology 39: 26-32.
26. Lodriche SS, Soltani S, Mirzazadeh R (2013) Inventors and assignees. Silicon nano carrier for delivery of drug, pesticides and herbicides, and for waste water treatment. United States patent.
27. Rouhani M, Samih MA, Kalantari S (2012) Insecticide effect of silver and zinc nanoparticles against Aphis nerii Boyer De Fonscolombe (Hemiptera: Aphididae). Chilean J Agric Res 72: 590-594.
28. Chakravarthy AK, Chandrashekharaiah, Kandakoor SB (2012) Bio efficacy of inorganic nanoparticles CdS, Nano-Ag and Nano-TiO2 against Spodoptera litura (Fabricius) (Lepidoptera: Noctuidae). Curr Biotica 6: 271-281.

*Corresponding author: : Fawzy ZF, Email: zakaria6eg@gmail.com