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Mini Review

Use of Nanocomposites to Production Enhanced Efficiency Fertilizers

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Abstract

Nanotechnology has developed in.LLL recent years and attracted scientific interest in several areas. Production or transformation of polymers on nanoscale, generates materials with applicability in many sectors, including agriculture. In this paper we will show the use of nanocomposites in production of fertilizers, aiming to increase the efficiency of this important agricultural input. The use of enhanced efficiency fertilizers based on nanocomposites can help solve classic agricultural problems such as nutrient loss, and generate agronomic, economic and environmental benefits.

Introduction

Nowadays, the use of nutrients from mineral fertilizers is necessary to ensure crops reach high productivities. Soil, plant, weather and crop management factors, can contribute to low efficiency of fertilizers. Some estimates show the Nutrient Use Efficiency (NUE) in the world are below 50%. This low efficiency may cause economic, environmental and social damage, affecting the sustainability of agricultural production [1]. In view of this problem, it is urgent to adopt strategies and technologies that promote NUE increase. In this sense, use of enhanced efficiency fertilizers appears an interesting option to help solve this problem [2-4]. In this short review, let's approach some problems faced by agriculture, and development of technologies based on nanocomposites, such as alternatives to solve these problems.

Enhanced Efficiency Fertilizers

The conventional fertilizers are sold in grain or dust form. One way to enhance efficiency of fertilizers, would be coating the grains with materials with ability to release nutrients in a controlled form (quantity a function of time), or, encapsulate the nutrients in an inorganic matrix that also has ability to control release. Some nanocomposites were studied to enhance fertilizers efficiency, among them stands out Layered Double Hydroxides (LDHs) [5-7], chitosan [8], carboxymethyl-cellulose [9], polyurethane [10], among others.

When input this technology in fertilizers, are generated products with release profile nutrient release similar of plant nutrient demand (Figure 1). This contributes to loss reduction and increases the agronomic efficiency of fertilizers.

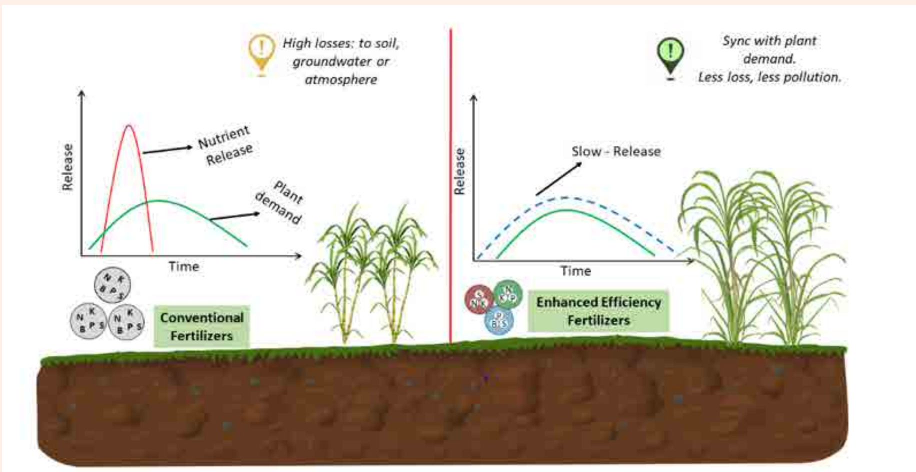

Figure 1: Comparative scheme between conventional fertilizers and enhanced efficiency fertilizers.

1. Nitrogen (N)

One of the great problems of agriculture is the loss of N in fertilizers based on urea. This loss occurs by ammonia (NH_3^+) volatilization, as a result of fast urea hydrolysis in inadequate environmental conditions. The incorrect management of urea-based fertilizers can make N losses reach 70%. One way to solve this problem is to produce fertilizers that release urea gradually, this way the hydrolysis occurs slowly and N losses decrease.

In this sense, *Pereira et al.* [11] produced urea-based fertilizers from the mix of polymer (polyacrylamide), paraformaldehyde, and montmorillonite clay. The produced materials used in bioassays, where they evaluated the N volatilization and NUE in the grass (test plant). The results showed when compared with conventional urea, the polymeric mix in a proportion of montmorillonite, urea, and paraformaldehyde 1:1/1 reduced volatilization 4.3 times. This same mix in proportion 1:4/0.5, increased grass production 53%, and NUE of N 60%.

Another usual problem in agriculture too N associated is nitrate (NO_3^-) leaching. The majority of soils have electronegativity character, due to this, some anions such as NO_3^- tend to stay free in soil solution and be easily leached [12]. Beyond nutrient loss, the NO_3^- generate environmental damages such as groundwater contamination and lake and rivers eutrophication. The use of slow-release fertilizers, to mitigate this problem, is a promising alternative. The application of nanocomposites to produce these fertilizers too presents good results. *Olad et al.* [13] produced a nanocomposite using sodium alginate, acrylic acid, acrylamide, and nanoparticles of silica obtained by carbonization rice husk; they used polymer as a slow-release fertilizer matrix. Testing nutrient release from fertilizer, in the soil, they found conventional fertilizers released all nutrients in first hours after application, while encapsulation in nanocomposites promoted a decrease in release profile of nutrient, after 30 days, had released only 70% of nutrient. These characteristics, the fertilizer would be a good alternative to systems with high leaching of NO_3^-.

2. Phosphorus (P)

Tropical soils are rich in Iron (Fe) and Aluminum (Al) minerals. These minerals have high interaction with P forms absorbed by plants ($H_2PO_4^-$ e HPO_4^{2-}), adsorbing them, and fix posteriorly, making P non-labile to plants sometime later [14]. This reaction makes P the most limiting nutrient and at the same time more consumed by agriculture in these regions.

Searching alternatives to minimize problems of P fixation in tropical soils, *Benício et al.* [6,15], produced a matrix to encapsulate P, based in LDHs. The materials presented a slow release profile, due to prolonged protection to phosphate ions. The use of LDHs resulted in greater dry mass production in corn plants, and increase agronomic efficiency of P in 6% in sandy soil, and 16% in clayey soil [6]. Beyond increasing moderately, the soil pH, the LDH matrix provides physical protection to phosphate ions, reducing your contact with soil particles. In literature are found many papers showing LDHs potential to use as enhanced efficiency fertilizers [16-18].

3. Boron (B)

Boron is a micronutrient with many biological functions in plants, required in small quantities, your lack limits the crop production. In agriculture, B applied such as boric acid (H_3BO_3), easily leached species, these characteristics make difficult your management in many agricultural systems. *Castro et al.* [19] studied the use of LDHs to produce fertilizers able to reduce B leaching and increase crop production. The studies have shown that the boron intercalation in LHD reduced leaching of 44% to 9% on the first day after incubation when compared to H_3BO_3 use. The researchers reported that a slow-release profile is mainly responsible for the found result.

Final Considerations

Despite great advances in agriculture in recent years, classical problems still persist and need to be resolved to improve crop production. The majority part of production problems is related to the dynamic of nutrients in soils. In this short review, we saw examples, where some problems involving soil fertilization can be minimized with the use of nanocomposites to produce enhanced efficiency fertilizers. The nanocomposites have peculiar properties, originating from their physicochemical characteristics and your great variety, and may, used as a raw material in the production of modern fertilizers. Besides fertilizers, nanocomposites can be used with other purposes in agriculture. There is much to be studied and validated, however, we welcome the use of these materials in agriculture.

References

1. Salim N, Raza A (2020) Nutrient use efficiency (NUE) for sustainable wheat production: a review. J Plant Nutr 43: 297-315.
2. Jayanudin, Lestari RSD (2020) Fertilizer encapsulation to improve the nutrients use efficiency of plant through slow/controlled release to ensure food security. Rasayan J Chem 13: 1074-1082.
3. Guo H, White JC, Wang Z, Xing B (2018) Nano-enabled fertilizers to control the release and use efficiency of nutrients. Curr Opin Env Sci Health 6: 77-83.
4. Kalia A, Sharma SP, Kaur H (2019) Nanoscale fertilizers: harnessing boons for enhanced nutrient use efficiency and crop productivity. In Nanobiotechnology Applications in Plant Protection . Springer, Cham pp. 191-208.
5. Castro G, Zotarelli L, Ferreira J, Mattiello E, Tronto J (2019) Boron Release and Leaching from Layered Double Hydroxides Intercalated with Borate. In ASA, CSSA and SSSA International Annual Meetings. ASA-CSSA-SSSA.
6. Benício LPF, Constantino VRL, Pinto FG, Vergütz L, Tronto J, et al. (2017) Layered double hydroxides: New technology in phosphate fertilizers based on nanostructured materials. ACS Sustain Chem Eng 5: 399-409.
7. Everaert M, Warrinnier R, Baken S, Gustafsson JP, De Vos D, et al. (2016) Phosphate-exchanged Mg–Al layered double hydroxides: a new slow release phosphate fertilizer. ACS Sustain Chem Eng 4: 4280-4287.
8. Li T, Gao B, Tong Z, Yang Y, Li Y (2019) Chitosan and graphene oxide nanocomposites as coatings for controlled-release fertilizer. Water Air Soil Poll 230: 146.
9. Olad A, Zebhi H, Salari D, Mirmohseni A, Tabar AR (2018) Slow-release NPK fertilizer encapsulated by carboxymethyl cellulose-based nanocomposite with the function of water retention in soil. Adv Mater Res-Switz: C 90: 333-340.
10. Jia C, Zhang M, Lu, P (2020) Preparation and characterization of polyurethane-/MMT nanocomposite-coated urea as controlled-release fertilizers. Polym-Plast Technol and Mat pp. 1-10.
11. Pereira EIA, Nogueira AR, Cruz CC, Guimarães GG, Foschini MM, et al. (2017) Controlled urea release employing nanocomposites increases the efficiency of nitrogen use by forage. ACS Sustain Chem Eng 5: 9993-10001.
12. Van Raij B (2011) Fertilidade do solo e manejo de nutrientes. International Plant Nutrition Institute (IPNI) pp. 420.
13. Olad A, Gharekhani H, Mirmohseni A, Bybordi A (2017) Synthesis, characterization, and fertilizer release study of the salt and pH-sensitive NaAlg-g-poly (AA-co-AAm)/RHA superabsorbent nanocomposite. Polym Bull 74: 3353-3377.
14. De Campos M, Antonangelo JA, Alleoni LRF (2016) Phosphorus sorption index in humid tropical soils. Soil Till Res 156: 110-118.
15. Benício LPF, Eulálio D, Guimarães LDM, Pinto FG, Costa LMD, et al. (2018) Layered double hydroxides as hosting matrices for storage and slow release of phosphate analyzed by stirred-flow method. Mater Res 21.
16. Bernardo MP, Guimarães GG, Majaron VF, Ribeiro C (2018) Controlled release of phosphate from layered double hydroxide structures: dynamics in soil and application as smart fertilizer. ACS Sustain Chem Eng 6: 5152-5161.
17. Qiao W, Bai H, Tang T, Miao J, Yang Q (2019) Recovery and utilization of phosphorus in wastewater by magnetic Fe_3O_4/Zn-Al-Fe-La layered double hydroxides (LDHs). Colloid Surface A 577: 118-128.
18. Borges R, Wypych F, Petit E, Forano C, Prevot V (2019) Potential sustainable slow-release fertilizers obtained by mechanochemical activation of MgAl and MgFe layered double hydroxides and K_2HPO_4. Nanomaterials- Basel 9: 183.
19. De Castro GF, Ferreira JA, Zotarelli L, Mattiello EM, Novais RF, et al. (2020) Layered double hydroxides intercalated with borate: effect of fertilization on boron leaching and successive sunflower cultivations. New J Chem 44: 10042-10049.