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Sustained Release Fertilizers for Modern Agriculture

Karuna Jain[1] and Rahul Kumar Dhaka[1]
[1]Department of Chemistry, College of Basic Sciences and Humanities, Chaudhary Charan Singh Haryana Agricultural University Hisar, Haryana-125004

ARTICLE ID: 41

Abstract

The burgeoning global population has led the excessive use of chemical fertilizers to fulfil the food demand. These chemical fertilizers are cost-intensive and release nutrients quickly. A small fraction of applied nutrient is absorbed by plants and a significant fraction of itgets lost causing harm to both the agriculture and environment. The smart sustained release fertilizers such as controlled and slow release fertilizers can be the suitable alternatives of these chemical fertilizers. These fertilizers regulate the nutrient supply providing right nutrient for right duration, at the right rate, and at the right position. The utilization of agricultural residue-derived biocharas a sustained release fertilizer can increase nutrient use efficiency (NUE) and crop productivity. Biochar-based sustained release fertilizers deliver nutrients gradually for prolonged time. A cost-effective and eco-friendly biochar-based sustained release fertilizer has potential to be employed in modern agriculture with multiple environment benefits.

Keywords: Agriculture, Biochar, Crop productivity, Nutrient use efficiency (NUE), Soil health. Soil health. Sustained release fertilizers.

Introduction:

In the era of science and technology, agricultural productivity and crop quality may be improved in a sustainable and innovative manner. The sustainable fertilizers to meet the ever-growing demand of food are the examples of technological advances in modern agriculture over the conventional practices. Traditional agricultural practices use high amount of agrochemicals to protect the plants and increase the crop yield. As per the reports, pesticide consumption has been increased by 36% during recent two decades (2000-2019);being 4.2 million tonnes in 2019.[1]In the same year, consumption of nitrogen (N), phosphorous (P), potassium (K),known as macronutrients, was 189 million tonnes in 2019.[1]Thefertilizersare significantly lost to the environment through different mechanisms like leaching,

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volatilization, hydrolysis, degradation and photolysis leading to low nutrient use efficiency (NUE). NUE of chemical fertilizer is about 30 %-35% for nitrogen (N), 18 %-20% for phosphorus (P), and 35 %-40% for potassium (K).[3]Further, environmental and ecological problems like eutrophication, deterioration of soil and food quality, and climate change are contributed by excessive use of fertilizers and loss thereof.

The above said issues associated with the excessive use of chemical fertilizers in agricultural practices can be mitigated by introducing eco-friendly smart sustained release fertilizers. These sustained release fertilizers are classified as slow-release fertilizers (SRFs) and controlled release fertilizers (CRFs). These smart fertilizers may provide demand-based supply of nutrients to the plants. The effective synchronization of demand and supply of nutrients may help in plant growth and improved crop productivity. The scientists must work on economic, efficient, locally available, carbon negative materials for the development of robust, viable, and smart sustainable fertilizers.

Sustained release fertilizers:

Controlled and slow release fertilizers are the sustained release fertilizers which on supplementation in soil increase the nutrient use efficiency (NUE) and water use efficiency (WUE). In controlled release fertilizers (CRFs) the nutrient release pattern, rate and duration can be controlled by encapsulation and surface coating on to the carrier material. The controlled supply of the nutrient to the plants improves it use efficiency and minimize the loss. Slow-release fertilizers (SRFs) release nutrients gradually for longer duration. Thus, the application of these fertilizers in agricultural practice as nutrient input can reduce the production cost leading to increase the farmers' income, improve the agriculture productivity and minimize the environmental pollution. Currently, the sustained release fertilizers available in the market are milorganite, schultz, osmocote, scotts, ecoscraps (SRFs) and methylene diurea, urea formaldehyde, urea acetaldehyde, urea form and sulfur coated urea (CRFs).

Advantages of controlled and slow release fertilizers:

- CRFs and SRFs deliver nutrients at a sustainable rate for extended period of time in soil to increase nutrient use efficiency (NUE), reduce the application, labour cost, and mitigate the agro-environmental issues.

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- CRFs and SRFs enhance the bioavailability of nutrients in soil by adjusting the soil *p*H.
- CRFs and SRFs may decrease the fertilizer requirement by 20%-30%.[2]

Materials like polymers, clays, hydrogels, zeolites, and biocharcan potentially act as sustained-release fertilizer. Out of these, biochar due to its viable properties and distinctive features matches well with the profile of sustained release fertilizers.

Biochar-Based sustained-release fertilizer:

Biochar is a carbon negative material synthesised from agricultural and fruit wastes via thermal carbonization processes like pyrolysisunder oxygen limited conditions. Other methods of lignocellulosic biomass carbonization are gasification, hydrothermal carbonization, microwave and torrefaction. According to International Biochar Initiative (IBI), biochip is a stable carbon rich material and persists in soil from decades to millennia. Biochar has prominent physical and chemical properties such as large surface area, pore volume, porosity, adsorption capacity and more active sites, abundant surface-active functional groups that lead to increase the nutrient and water retention capacity. Therefore, biochar-based fertilizers may release nutrients at a sustainable rate for extended period of time and can be used for longer duration. These fertilizers can be developed via impregnation, co-pyrolysis, encapsulations, surface coating methods to enrich biochar with nutrients and to increases its efficacy as fertilizer.

Biochar supplementation in soil improves the soil health, elevate soil's water retention capacity and mitigate environmental issues. Biochar in soil leads to the formation of biochar-mineral complexes which enhances the mycorrhizal associations thus enhances nutrient holding capacity and releases the nutrients slowly. Hence, the sustained-release behaviour of biochar enhances the NUE, WUE, bioavailability of nutrients and consequently increases the crop productivity. Further, these fertilizers can enhance crop productivity by 10 % to 20% and lower the use of fertilizers by 30 % to 50%.[4.]

Conclusion

The nutrient use efficiency (NUE) of chemical fertilizer is generally very low. Sustained release fertilizers enhance NUE and reduces the nutrients loss as well. Biochar, prepared using agricultural residues, is a carbon negative material with huge potential to be used as a carrier material for sustained release fertilizers development. The conversion of

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agricultural waste into value-added products like biochar is a win-win strategy as it helps in waste management and has many agro-environmental benefits. Utilization of biochar-based sustained release fertilizer is an efficient, robust, economically feasible and environment friendly approach. These fertilizers not only stimulate the crop productivity but also reduces the environmental pollution. Application of these fertilizers will decrease the agricultural expenses and enhance farmer's income. The use of biochar in modern agriculture is a multifaceted strategy that fully compile with circular economy and zero-waste concept by tying waste management, soil management, up gradation of food quality and production together in a virtuous cycle. Introduction of biochar-based sustained-release fertilizers in modern agriculture is an auspicious strategy to achieve the sustainable agricultural goals.

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