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Sodium Alginate Based Slow-Release Fertilizers

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Soil resources are often the focus of attention because their quality is deteriorating or degrading. Human activities, agriculture, households, and industry have contributed to this decline. Effective use of fertilizers is essential for sustainable agricultural productivity and food security, where phosphorus (P), nitrogen (N), and potassium (K) are the vital input elements for crops growth. The control of these nutrients in soil has been considered as a global challenge for the agricultural sector without sacrificing resources and the environment. Controlled release fertilizers using a biodegradable natural polymer is one viable option for efficient nutrient management and also minimize environmental pollution that came from leaching of fertilizers and other chemical inputs.

Need for slow-release fertilizers

The urge on developing countries to increase the global food production is due to thriving population. In such case, fertilizers play an important role in facing the challenge in increasing the crop yields and supporting food production. Among 17 essential nutrients, Nitrogen (N), Phosphorous (P), Potassium (K) are mostly required in higher quantities for the crops. However, in an ease of increasing the production of crops globally, these nutrient fertilizers were applied in soil in excess quantity. Over use of NPK fertilizers largely deteriorated the soil health due to its residual effect. This results in soil degradation, nutrient imbalances, environmental and water pollution. In order to optimize the usage of fertilizer for long term viability of agriculture, there is a perception for efficient and controlled release of fertilizer in soil. So, the slow-release fertilizer is designed in making the availability of nutrients from fertilizers to crops in controlled manner by minimizing losses due to leaching or volatilization and also increasing the nutrient use efficiency of fertilizers in soil.

Slow-release fertilizers (SRF)

The type of fertilizers which contain nutrients with slow/delayed release to be absorbed by crops than the conventional fertilizers, e.g., urea, ammonium nitrate or potassium chloride. The rate, release duration and pattern of fertilizers are well controlled by SRF. The mechanisms involved in the slow release to plants are semi-permeable membrane making the fertilizers with low water solubility, proteinaceous materials, occlusions and by other process. The main highlights of SRFs are higher nutrient use efficiency, prevents contamination of various natural resources, safeguards the biota in soil and supplies the optimum amount of nutrients in sustained way. The slow release of fertilizers is due to reduced solubility in water, prevents the loss of nutrients from volatilization thereby increasing the nutrient use efficiency of fertilizers, reduces application rates and minimizes the pollution in soil and water bodies caused by excess fertilizer application.

Biopolymers

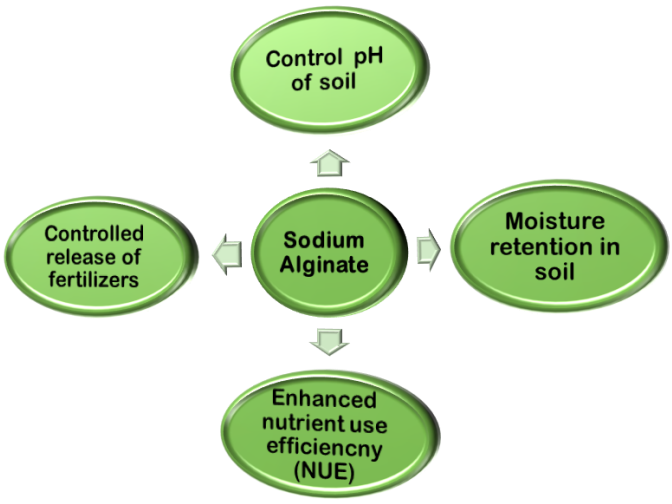
Biopolymers are natural polymers which are derived from natural sources like plants, bacteria, fungi and animals. Even though synthetic based SRFs are in market, there is need for biopolymer based SRFs for the concern of soil and environmental ecosystem due to its advantages like easy biodegradability and eco-friendly nature over synthetic polymers. It also provides a way for effective utilization of natural resources (Table 1).

Table 1. Various biopolymers and its sources

Biopolymers	Sources
Starch	Cereals, grains, and potatoes
Chitosan	Shells of crustacean
Guar gum	Guar seeds
Alginate	Brown algae
Gelatin	Hydrolysis of collagen
Lignin	Support tissues of most plants

(Tariq *et al.*, 2023)

Fig. 1. Applications of sodium alginate in soil



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Sodium alginate (SA) based biopolymer fertilizer composites

Alginate is a natural polymer derived from brown sea weed. Most commonly used is sodium alginate type. The natural polymers as a composite for fertilizer for controlled release is a major focus in recent years, as it can adsorb and release the nutrients for long period of time based on the crop duration. It is an eco-friendly, biodegradable, cost effective slow-release natural polymer and other applications in soil (Fig. 1). Further, it also reduces the costs of repeated application due to the sustained release of nutrients when it is loaded with mineral fertilizers. In addition, it improved the water use efficiency, fertilizer morphology and fertilizer hardness respectively. For encapsulation of NPK with SA, the fertilizer solution has to be mixed with SA. However, due to high solubility of NPK fertilizers in aqueous solution, some of nutrient ions will be lost on encapsulation process. So, fertilizer solution has to be cross linked with a cross linker like citric acid (CA), $CaCl_2$, polyvinyl alcohol (PVA), gluteraldehyde, epichlorohydrin, isoprene, etc., for better encapsulation. The cross-linking agent forms a three-dimensional network structure that entraps the nutrients ions in the biopolymer matrix. Mesias et al. (2019) observed that the coated NPK fertilizer based on CA cross-linked chitosan/alginate (Chi/Alg/CA/ NPK) was successfully prepared as colloidal dispersion. The highest encapsulation efficiency, which ranges from 85–89%, was observed in 1:1 Chi/Alg ratio with 10% citric acid formulation. Besides, nutrient release from sodium alginate-based fertilizer composites is mainly controlled by the mechanism of diffusion when applied in soil.

Conclusion

Sodium alginate (SA) exhibits potential characteristics for the sustained release of minerals nutrients for the crop growth and its performance as it can able to accumulate and retain substantial quantities of ionic nutrients. It helps to maintain an optimum rate of fertilizer application and also prevent from excess loss of fertilizers. It is an option for the application of slow-release fertilizers in an eco-friendly aspect.

References

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