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Nutrient Encapsulation for Enhancing Yield and Sustaining Soil Health

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Abstract

Fertilizer is a key and costly input in Indian agriculture. Import of the fertilizers is the major burden to the exchequer of the government. Normally fertilizers are broadcasted. Many times, straight fertilizers are used as the source of nutrients. Application of straight fertilizer leads to loss of nutrient through leaching and volatilization. In order to manage these losses split application is recommended for soluble fertilizers especially for urea and muriate of potash. Now-a-days, newly emerging technology namely "Nutrient encapsulation" which reduces the nutrient losses in the soil and helps in improving the nutrient use efficiency and yield.

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Introduction

India is the third largest fertilizer user but the average rate of nutrient application is only 85 kg ha^{-1}. The use efficiency of fertilizers is determined by factors *viz.*, crop variety, soil type, irrigation *etc.* The Government implemented the "New Fertilizer Policy", from April 2003, which allowed urea manufacturers to market initially 25 percent and subsequently 50 percent of their production outside the purview of distribution control. The efficiency of fertilizer use could be improved through fertilization practices that include an application of macronutrients and micronutrients according to crop requirements (Mala, 2013). Application of fertilizer by broadcasting by the farmers leads to loss of nutrient through leaching and volatilization. In order to manage these losses, split application is recommended for soluble fertilizers especially for urea and muriate of potash. Even then, improper maintenance of management practices leads to poor use efficiency of fertilizers. Hence, the newly emerging technology namely "Nutrient encapsulation" helps in improving the nutrient use efficiency and yield of crops.

Common Methods to Enhance Nutrient Use Efficiency

By changing the nature of fertilizer materials in such a way that nutrient release is regulated throughout the active phase of nutrient uptake by the plant. Use of synthetic nitrification inhibitors, chemically modified fertilizers to reduce their dissolution and mineralization, coating with suitable materials to control dissolution and release of N, mixing or coating with natural organic compounds possessing urease and nitrification inhibiting properties, increasing the size of the granules that will regulate dissolution and nitrification are common Nitrogen management to increase N use efficiency.

Cowdung and pressmud have been effectively utilized in coating single super phospahe. By this process the amount of P fixation in soil is reduced and response for P application

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is higher. By using the FYM 750 kg acre^{-1} + recommended dose of phosphorus per acre under anaerobic decomposition increase the availability of P is improved significantly. Enriching the micronutrients with FYM and application also improves their availability.

Fertilizer Capsules

Required quantity of the water-soluble fertilizer is made into a capsule with up to four 0.0005 inch or pin hole size punctures in polyethylene films. Soil moisture enters the capsule, dissolves a little of the fertilizer which is then released from the capsule and made available to the plant, when the plant due to moisture can use the fertilizer, and that after three months of a normal growing season 10-20% of the fertilizer, in capsules originally containing 1 gram, still remains in the capsules ready for further fertilization. The capsules also can be utilized for top dressing also (US Patent No. 3,059,379, 1992).

Nutriseed Packs

Nutri seed pack is the technology developed by the Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore.

Nowadays labour scarcity prevails everywhere and it delays timely sowing of seeds, fertilizer application, *etc*. Fertilizers are costly input in the crop industry. Delayed applications of fertilizers are major reasons for the low yield of crops. In the present situation, Nutriseed Pack placement would help farmers to achieve the expected yields.

Normally fertilizers are broadcasted in crop fields. In normal surface application of the fertilizer, the fertilizer use efficiency is low. Nutriseed pack is a tubular assembly for placing in soil to raise a plant. Nutriseed pack technique helps in improving the efficiency and yield in May crops. Each Nutriseed pack contains seed at the top of the capsule, enriched manure in the middle and encapsulated fertilizer at bottom.

By placing a Nutriseed pack in soil, plants can be established and it gives support for each plant with optimum nutrient supplyand enables the fullest utilization of nutrients by plants without any wastage of fertilizer nutrients. Nutriseed packs are meant for single time placement in soil at the time of sowing to act as nutrient pile for slow release of nutrients. With placement of Nutriseed packs build up in available N, P and K occurred in root zone soil up to the harvest stage. Horizontal placement of Nutriseed pack is equally effective as that of vertical placement.

Nutriseed pack placement has been brought out as an alternative means of fertilization in crop production in the place of fertigation or surface broadcast. Yield improvement of 10-30 percent for Nutriseed pack placement has been recorded in major cereal and vegetable crops over conventional method of fertilizer application. The adoption of this technique lies with the production of Nutriseed packs in large numbers and making it available to the farmers adequately at the time of crop season. By the use of automated machineries Nutriseed packs can be produced at cheaper cost, thereby reducing cost of crop production for farmer. Cost reduction is due to savings in fertilizer input, cost on labour involved in fertilizer application.

Microencapsulation of Fertilizers

The encapsulation of commercial fertilizers using polymer films to protect the nutrients from rapid stabilization reactions in soils and control their release into the soil solution during plant growth. Nutrient release of coated fertilizer specifically micronutrients happens based on soil moisture content and/or temperature, soil pH, ionic content *etc*. The nutrient release mechanism is based on either direct diffusion through a polymer film or by decreasing the rate of product hydrolysis. The properties and structure of polymers together with the architecture of microcapsules influence the release of encapsulated fertilizer.

Microencapsulation of fertilizers produces tiny capsules (*i.e*., µm diameter) that have several nutritional advantages.

Advantages of Microencapsulation

• Enhancement of contact surface that for absorption and, thus, increase in bioavailability

• Low cost of production.

• Biodegradability and biocompatibility with food and the environment.

Nano-Encapsulation

Nano-fertilizers are nutrient carriers, whose substrates in the range of nano-dimension (1-100 nm), capable of supplying nutrients to the plant system for an extended period of time without associated environmental hazard (Subramanian, *et al*., 2017). Nanoencapsulation of fertilizers ensures controlled release and targeted delivery of nutrients required for efficient nutrient uptake and enhanced growth of agricultural crops. Encapsulation of fertilizers within a nanoparticle is one of these new facilities which are done in three ways.

a) The nutrient can be encapsulated inside nonporous materials,

b) Coated with thin polymer film, or

c) Delivered as particle or emulsions of nanoscales dimensions.

Nanostructured formulation might increase fertilizer efficiency and uptake ratio of the soil nutrients in crop production, and save fertilizer resource (Sharma *et al*., 2021).

Hollow core shell nanomaterials and nanostructures have become an important research area due to their potential applications in the fields of agriculture. Research reports

indicates that a nano-sized Mn-carbonate hollow-core shell loaded with $ZnSO_4$ regulated Zn release in solution, more slowly than that the $ZnSO_4$ salt, satisfying plant root demand through the process of dissolution and ion exchange reactions.

Conclusion

There are varieties of new techniques available to enhance the nutrient use efficiency. Encapsulation of nutrients is a growing technology with different dimensions to increase the nutrient use efficiency and enhance yield and quality of crops. Hence, the new avenues have to be captured for effective use of nutrients both to sustain soil health and increase the productivity. Based on the necessity, cost effectiveness and environmentally safe technologies can be adopted to sustain soil health.

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