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Slow-Release Fertilizers: A Scope to Efficient Agriculture in Nepal

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Abstract

Slow and controlled-release fertilizers are proposed as a solution to improve the nutrient use efficiency of plants. This review article provides a general look on application of quick- and slow-release fertilizers for commercial crop producers, researchers, and students who are interested in nutrient management for commercial crop production. They are also very useful in the soil which is more proned to nutrient loss through leaching, flooding and runoff. Using fertilizers without identifying and calculating right source and right amount and their application all at once without timing applications to the plants' growth stage pattern can expose plants to burning, toxicity and nutrient loss. It frequently means that nutrients will not be available to plants when they need them. In this case, slow release of nutrients not only protect plants from burning and other toxic symptoms, but also be available to the plants whenever they demand for nutrients. Unlikely, Slow-release fertilizers are more expensive and less water soluble than traditional fast-release fertilizers. Slow-release fertilizer works depending on many factors, including microbial activity, temperature, and moisture in the soil. We can sum up as Slow-release fertilizers are also the alternatives to air and soil polluting quick releasing fertilizers and inefficient fertilizers application malpractices. This review article tries to reveal how the research organizations are using and recommending the slow-release fertilizers in different crops in Nepal.

Keywords: Slow-Release Fertilizers, Efficiency, Malpractices

Introduction

The fertilizer industry faces a continuing challenge to improve its products to increase the efficiency of their use, particularly of nitrogenous fertilizers, and to minimize any possible adverse environmental impact. This is done either through improvement of fertilizers already in use, or through development of new specific fertilizer types (Maene, 1995; Trenkel *et al*., 1988) cited by Trenkel, 2010) [18].

A fertilizer containing a plant nutrient in a form which delays its availability for plant uptake and use after application, or which extends its availability to the plant significantly longer than a reference 'rapidly available nutrient fertilizer' such as ammonium nitrate or urea, ammonium phosphate or potassium chloride (Trenkel, 2010) [18]. One-time fertilization with controlled-released fertilizer (CRF) is a promising way for reducing labor cost, increasing nitrogen use efficiency (NUE) and alleviating environmental pollution in winter wheat (Triticum aestivum L.) cultivation (Cui *et al*., 2022) [5]. CRFs provide a promising alternative for improving the management of nutrient supply and decreasing environmental pollution while maintaining good quality and high crop yields. Nutrients are released in a controlled manner either by releasing nutrients by imperfections in the coating of the prill or the use of uncoated fertilizer prills in the formula (Maya *et al*, 2021) [12].

Slow- and controlled-release fertilizers (S/CRFs) are considered as novel and revolutionary approaches in the field of fertilizer synthesis (Aiman *et al*, 2021) [3]. They also forwarded that S/CRFs are seen as economical and environment-friendly alternative to chemical fertilizers. According to AAPFCO (1997): There is no official differentiation between slow-release and controlled-release fertilizers (Trenkel, 2010) [18]. Controlled and slow-release fertilizers are fertilizers that release nutrients over a longer period of time as compared to the conventional fertilizers. These types of fertilizers are produced either by the condensation reaction or by encapsulation or coating of the fertilizer's granule with polymers, sulfur and other types of coatings. (Maya *et al*., 2021) [12].

The longevity of the controlled and slow-release fertilizers is dependent on its water solubility, permeability of the coating and the temperature of the soil where it is applied. The slow and controlled release of nutrients helps plants grow efficiently, thereby resulting in higher yields (Future Market Insights). CRFs are fertilizers that release an amount of nutrients not exceeding 75% of the total in the first 28 days of use at a temperature of 25 °C (European Commission, 2020). Thereby, the soil absorption of nutrients is optimized, and their dispersion in the environment, especially in groundwater, is strongly limited. The use of CRFs also includes some drawbacks, such as a lack of correspondence between laboratory and field tests, high production costs, difficulty in storage, and loss of compounds that can pollute the soil. In fact, the most common type of CRFs is characterized by a conventional fertilizer enclosed in a coating or dispersed in a matrix, able to regulate nutrient release, that mainly consists of petroleum-based plastic. (Trenkel, 2010 [18], Azeem *et al*., 2014). The mechanism of controlled release is regulated first by the progressive degradation of the coating and second by the osmotic pressure inside the core; thereafter, high hydrophilic and environmentally green compounds must be considered to avoid the pollution of soil after coating degradation (Silvia. Barbi *et al*., 2020) [16].

Natural SRFs include plant manures, such as green manure or cover crops, all animal manures (chicken, cow, and poultry) and compost (Shukla *et al*. 2013) [15]. Because of their organic nature, these must be broken down by microbial activity before the nutrients can be released to crops. In general, organic fertilizers may take a long time to release nutrients, and these nutrients may not be available when the plant needs them. The duration of nutrient release of this type of organic fertilizers mainly depends on soil microbial activity that is driven by soil moisture and temperature. (Guodong Liu *et al*., 2021 in https://edis.ifas.ufl.edu/publication/HS1255). Controlled-release urea (CRU) has been shown to improve nitrogen use efficiencies (NUEs) and yields in wheat and maize crops, although high cost has limited its use (Zheng *et al*., 2016) [20].

Advantages of Controlled/ Slow-Release Fertilizers

- The application of CRFs and SRFs can potentially decrease fertilizer use by 20 to 30 percent of the recommended rate of a conventional fertilizer while obtaining the same yield (Trenkel 2010) [18].
- These make the possibility of availability of nutrients to the plants in late stages of growth also. This is possible due to their long-time persistence in soil or in the plant body.
- Minimization of fertilizer-associated risks such as leaf burning, water contamination, and eutrophication (a process where water bodies receive excess nutrients). The slow rates of nutrient release can keep available nutrient concentrations in soil solution at a lower level, reducing runoff and leaching losses.
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Disadvantages of Controlled/ Slow-Release Fertilizers

- Slow-release fertilizers may sometimes stand the risk of increased harmful leaching events. This situation arises as a result of their reliance on microbial digestion to stimulate nutrient availability. When satisfactory conditions for microbial activity follow after the cropping cycle, available surplus nutrients can be pollutants irrespective of the source.
- Coated controlled-release fertilizers require more production costs than quick-release fertilizers.
- Nutrient deficiencies may materialize if nutrients are not released as predicted due to either low temperatures, flooded/droughty soil, or weak activity of soil microbes.

Types of Slow-Release Fertilizers

- Organic fertilizers: plant manures, such as green manure or cover crops, all animal manures (chicken, cow, and poultry) and compost
- Synthetic fertilizers: Controlled-release fertilizers are typically coated or encapsulated with inorganic or organic materials ex: Sulphur coated urea, polymer coated urea, Neem Coated Urea, Urea Briquettes

Scope of Slow-Release Nitrogen Fertilizers in Nepal:

Soils in Nepal across hills and mountains are light-textured, shallow, and susceptible to erosion while low-lying areas including Terai have heavy textured soils with greater depth, and prone to flooding. Majority of the soils in the country are acidic, low in organic carbon and total nitrogen, and deficient in zinc, boron, and molybdenum. Soil fertility is in declining trend mainly due to soil nutrient mining, depletion of soil organic matter, soil erosion in hills and mountains, and inappropriate use of chemical fertilizers in Terai region (Tripathi *et al*., 2022) [19].

The efficient utilization of nitrogen in crop must include some management strategy that includes right source and right rate in right time and right place. The management practices involving new technologies should be adopted to increase NUE, maintained soil nutrient status and crop productivity. Some of the commonly available strategies to increase NUE and crop yields are real-time N management using Leaf Color Chart (LCC), and Green Seeker (GS) optical sensor, use of controlled release fertilizers such as Polymer Coated Urea (PCU) and improved application method such as Urea Deep Placement (UDP) (Cameron *et al*., 2013; Ladha *et al*., 2005). Recently, improved application methods such as urea deep placement (UDP) or root zone application has been found to increase NUE and yields and reduce N losses to the environment. (Agyin-Birikorang *et al*., 2018, Singh *et al*, 2010) [2, 17]. Similarly, Pandit *et al*, (2022) [14] also forwarded that N input in UB was reduced by 25% from the recommended N rate of 200 kg ha−1 considering its expected higher NUE. In the UDP technique, urea is made into briquettes of one to three grams based on required N rate and placed at a depth of 7-10cm at a spacing of 40cm or at the centre of four rice plants within 7 days after transplanting (Gautam *et al*, 2017).

PCU is one of the promising controlled release nitrogen fertilizers coated with polymer, which is water insoluble and release N slowly synchronizing plant demand (Gautam *et al*., 2022) [11]. Similarly, urea briquette (physically compressed prilled urea to a larger granule, or urea super granule) applied as deep placement, commonly known as UDP (Deo *et al*., 2019), retains plant available N for a prolonged period (Gaihre *et al*., 2015).

Use of slow-release fertilizer in researches in different crops in Nepal:

International Fertilizer Development Center (IFDC) and the International Maize and Wheat Improvement Center (CIMMYT) through the Nepal Seed and Fertilizer (NSAF) project is testing the application of environmentally friendly slow-release nitrogen fertilizer in maize production. In particular, CIMMYT researchers examined the nutrient-use efficiency of briquetted urea and polymer-coated urea, also known as PCU (Beshir *et al* 2019) [1]. They also insisted that using regular urea, the efficiency of nitrogen use in maize is limited to 17 kg of grain per kg of nitrogen. Using briquetted urea and polymer-coated urea, efficiency increased to 24 and 28 kg of grain per kg of nitrogen respectively. A higher efficiency also suggests a reduction in losses to the environment (in https://www.cimmyt.org/news/slow-release-nitrogen-fertilizers-measure-up/). In research done in Boro rice in Bangladesh Agricultural University, Gairhe *et al*., (2016) [9], confirmed that UDP not only increases NUE and grain yields but also reduces negative environmental impacts including N2O emissions. He also insisted that UDP increased grain yield by 3-35% (average 21%) compared to broadcast PU in the dry (Boro) season.

In Nepal, Dhakal *et al*. (2020) [6] had reported that UDP technology reduced 25% nitrogen input while producing similar yields with relatively higher agronomic and economic efficiencies compared to recommended dose of fertilizers. (Due to slow-release mechanism and reduced losses, in most of the studies, both PCU and UDP have been applied in less amount compared to normal urea. Nitrogen rate in UDP and PCU reduced by up to 25–40% compared with government fertilizer recommendations (Baral *et al*., 2021; Dhakal *et al*., 2020) [4, 6]) cited by Gautam *et al*., 2022) [11].

CIMMYT after applying polymer-coated urea and briquetted urea, also forwarded that their use can allow reduce nitrogen inputs by as much as 30-40% in maize and 40-50% less nitrogen fertilizer application in wheat while maintaining the same yield levels achieved using current government fertilizer recommendations (Beshir *et al* 2019) [1]. Similar yield increase was found by (Marahatta, 2022) in rice. In maize, both polymer-coated urea and briquetted urea applied at 50% and 25% lower N rates respectively produced similar grain yields compared with Conventional Urea (Pandit *et al*., 2022) [14]. He also forwarded that N input in UB was reduced by 25% from the recommended N rate of 200 kg ha^{-1} considering its expected higher NUE in tomato. In terms of yield increase, Polymer Coated Urea, Sulphur Coated Urea and Urea Briquette increased yields by 21, 21 and 24% over those for Conventional Urea in Cauliflower (Pandit *et al*., 2022) [14]. Evaluating different nitrogen efficient management practice, Baral *et al*, 2021 [4] put forward that urea deep placement (Urea Briquette) produced the highest rice grain yield. He also insisted that placing urea 0.07–0.10 m deep at root zone which is commonly called urea deep placement (UDP) is an effective method for increasing grain yield and NUE.

Conclusion

Slow-release fertilizer are considered as time and labor efficient fertilizers. Different research organizations in Nepal have exposed the scope, utilization and applications of SLF in different crops. These fertilizers are advantageous in terms of time, labor, storage and nitrogen efficiency. Meanwhile, they have drawbacks in terms of money and techniques of their application. We can recommend SLF if the primary preference is to control the rate and pattern of nutrients release and also extend the longevity of your fertilizer application, use controlled-release fertilizers.

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