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Enhancing Fertilizer Utilization Effectiveness: An Extensive Review of Techniques

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Abstract

Phosphorus, potassium, and nitrogen, essential macronutrients, often pose the primary constraints in soil. They play a crucial role as supplementary factors in agricultural productivity. The production of nitrogen fertilizer in the cereal industry is primarily dedicated to three major crops: rice, wheat, and maize. Global food insecurity has become a pressing concern due to a growing population and shrinking farmland. While fertilizers have contributed to increased crop yields in the last six decades, their excessive application has had detrimental effects on the ecosystem. Inadequate use of fertilizers leads to reduced agricultural output, while excessive nitrogenous fertilizers negatively impact soil quality and the environment. Thus, adopting new approaches that preserve agricultural sustainability by achieving higher yields with reduced fertilizer usage and enhanced fertilizer use efficiency is imperative. This research aims to present methodologies that can effectively improve fertilizer use efficiency (FUE) to address this goal.

***Keywords**: Agricultural productivity, Ecosystem, Global food insecurity, Sustainable agriculture, Coordinated management, Fertilizer inhibitors*

INTRODUCTION

The world's population is expected to exceed 9 billion by 2050, necessitating a matching rise in agricultural output. More than half of the population between the ages of 32 and 45 relies on rice as their primary source of sustenance. With a growing population, more rice production is essential. However, several obstacles, such as a changing climate, increased pests and illnesses, more intense weather-related catastrophes, and a scarcity of farmable land, make this aim difficult to achieve. Inadequate levels of phosphorus and nitrogen, two essential nutrients for plant growth and development, are common causes of decreased agricultural yields. Increases in fertilizer use to increase agricultural products have plateaued, suggesting that the overuse of fertilizer is ineffective and harmful to the environment. Soil and farming systems globally suffer from nitrogen and phosphate deficits, requiring supplemental fertilizer to keep up with population increase. Even though nitrogen gas accounts for around 78% of atmospheric gases, it must be transformed into forms that are useable by plants before it can be used in agriculture. One facet of nitrogen use efficiency (NUE) is fertilizer use efficiency, which is the ratio of harvested crops to the quantity of fertilizer taken up by the soil. Volatilization, evaporation, and denitrification are the main pathways via which nitrogen is lost.

Approaches for Enhancing Fertilizer Effectiveness

Enhancing Fertilizer Performance through Coordinated Management

Integrated Nutrient Management (INM) refers to managing nutrients in a coordinated fashion by using a variety of on-site resources such as natural manure, residues from crops, nitrogen fixation by organisms, and chemical-based fertilizers. This method mixes all kinds of inorganic and biological nourishment to improve root development, nutrient delivery, and overall production to produce an optimum physicochemical environment. The yield and effectiveness of fertilizers may be enhanced by INM nutrient management thanks to interactions between various nutrients and macro/micro components. To maximize output, it is essential to use nitrogen from multiple resources in a calculated and efficient manner.

Improved Techniques for Fertilizer Application

Large granules, depth placement, and foliar spray are alternatives to traditional nitrogen fertilizer applications that reduce nitrogen loss while increasing fertilizer efficiency. In Australia, scientists found that broadcasting urea super granules increased rice yields by 37%, while deep implantation increased profits by 49%. This indicates that nitrogen recovery and utilization efficiency may be improved by employing customized fertilizers, such as sulphate and polymer-coated urea-based super granular with deeper placement. Loss of nutrients via volatilization during decomposition and immobilization may be minimized when fertilizers are applied by foliar spray. It has also been discovered that increasing nitrogen consumption efficiency in a damaged rice crop by placing urea mud balls in the submerged zone.

Utilization of Slow-Release Fertilizers

Slow-release nitrogen fertilizers have been shown to improve nitrogen usage efficiency, increase nitrogen recuperation, and decrease nitrogen losses. Fertilizers from nitrogen, including nitrate, are vulnerable to evaporation, whereas amide and ammonium fertilizers are volatile. Slow-release nitrogen fertilizers are more efficient since their release rate is calibrated to crop needs and soil nitrogen levels. Coated fertilizers that slowly release nutrients are widely used in India, but they are prohibitively expensive to produce and have minimal market penetration.

Application of Inhibitors

Nitrification, the process by which nitrifying bacteria convert nitrate into nitrite and ammonia, can be regulated through inhibitors. Soil colloids can absorb ammonium and retain it for longer, reducing leaching and denitrification rates and improving nitrogen use efficiency and crop output. The application of inhibitors to increase soil ammonium levels is recommended for enhancing fertilizer use efficiency (FUE) and crop productivity. The inhibitor DCD (Dicyandiamide) is commercially available and can be utilized in rice farming.

Crop Rotation

The technique of rotating the types of crops grown on a given land area from year to year is known as crop rotation. This method has been used to achieve maximum efficiency in the manufacturing of food. Incorporating legumes into cereal crop rotations is a tried-and-true approach that has been shown to boost food output. This is accomplished by the fixation of naturally occurring nitrogen within the ground and

increasing the soil's overall nitrogen content. As a direct consequence, there is less of a need for more fertilizers whenever the following crops are sown.

Implementation of Conservation Agriculture Methods

Putting into practice agricultural methods that save water and other resources may result in healthier soils, making more nutrients available to the plants. High decomposition rates brought on by extensive tillage methods speed up the process of depleting organic carbon in the soil, making the soil more prone to erosion. Long-term improvements to soil health may be accomplished by the gradual elevation of carbon content in the ground as well as the progress of a variety of mineral, chemical, and ecological soil qualities through the widespread adoption of current agricultural methods such as no-till farming practices and bed putting down roots, both of which integrate organic waste.

Effective Management of Crop Residues

The remnants of harvested crops that are left behind on the field are referred to as crop residue. Utilizing excess harvest leftovers may not only improve the soil's organic carbon content and the soil's general health, but it can also offer a more sustained supply of nutrients. It has been discovered that residues from cereal crops may provide between 40 and 100 kg/ha of nitrogen throughout the season. As a source of nitrogen, legume plant leftovers are handy since, in comparison to cereal crop residues, they have a lower carbon-to-nitrogen proportion and a greater concentration of nitrogen.

Green Manure Composting

Legume crops, capable of fixing atmospheric nitrogen in the soil, are preferred as green manure crops. For adequate green manuring, legume crops should possess characteristics such as rapid growth, short duration, high biomass production, atmospheric nitrogen fixation capability, and minimal cultural requirements. Legumes can store between 20 and 300 kg of nitrogen per acre per year.

Implementation of Precision Agriculture

Precision agriculture involves managing agricultural operations for optimal production, resource conservation, and environmental protection by utilizing information and technology to assess and understand temporal and spatial variability in the field. By leveraging GPS and GIS remote sensing technologies, precision farming enables the assessment of nitrogen variance in the area. It allows for the precise application of fertilizers at the appropriate time and in the exact amount.

Conclusion

Crop rotation, conservation agriculture practices, effective management of crop residues, precision farming techniques, and utilizing slow-release fertilizers and inhibitors collectively contribute to improved fertilizer recovery and, consequently, enhanced fertilizer use efficiency. These measures play a vital role in promoting agricultural sustainability.

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