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Nutrient Use Efficiency and Its Significance in Agriculture

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Introduction

India, after the scars like famines and food shortage across the country in the late 60s, has triumphed the self-reliant in food grain production by the green revolution. But that has left some harsh effects on our motherland soil like dwindled nutrient use efficiency, stumpy crop response ratio, negative soil nutrient balance, etc., which became a foremost concern in Indian Agriculture. As we fulfilled our goal of augmented food grain production, there is evidence of declining partial and total factor productivity and the solitary reason has been ascribed to diminishing native soil fertility Ramakrishna-Parama (2014). Consequently, the decreasing natural resource base has raised the alarm of sustainability and integrated resource management in the current agricultural system. One of those alarms is the concept of nutrient use efficiency (NUE) is very imperative in the cultivation of a crop. Soil characteristic features, fertilizer and water management approaches have an immense impact on NUE. The chief objective of the concept is to improve the efficiency of the cropping system by dropping the losses of nutrients and by maintaining the optimum quantity of nutrients in fertilizer dose. Hence, optimization goals inevitably comprise overall productivity as well as nutrient use efficiency. Global temporal trends in NUE vary from region to region. For the nutrients like nitrogen, phosphorus and potassium, partial nutrient balance (*i.e.,* the ratio of nutrients removed by crop harvest to fertilizer nutrients applied) and partial factor productivity (crop production per unit of nutrient applied) are drifting downhill in Latin America, India and China. Therefore, in order to improve the use efficiency of nutrients, various management practices and impact of environmental factors need to be understood and evaluate.

Nutrient use efficiency (NUE):

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The nutrient use efficiency is the output of any crop per unit of the nutrient applied under a specified set of soil and climatic conditions. The NUE can be expressed in several ways:

- **Partial factor productivity** (kg crop yield obtained per kg input applied).
- **Agronomic efficiency** (kg crop yield increase per kg nutrient applied).
- **Apparent recovery efficiency** (kg nutrient taken up per kg nutrient applied).
- **Physiological efficiency** (kg yield increase per kg nutrient taken up).
- **Crop removal efficiency** (removal of nutrient in harvested crop as a percent of nutrient applied).

Importance of NUE:

With an increased population around the globe, crop grain demand will raise to 100-110% by 2050 as compared to 2005 (Tilman *et al.*, 2011). A report reveals that there will be a requirement of 60% more cereal production by 2050 (FAO, 2009). With rapid urbanization cultivable land area is diminishing with time, so there is an emergency to necessitate the efficient employment of resources including nutrients as well as water.

Table 1. Factors affecting nutrient use efficiency:

	Type	Description
Plant factors	Genetic factor	Species/cultivar/genotype
	Physiological factor	• Roots: Length, density of main, lateral and root hairs • Higher shoot yield, harvest index • Higher nutrient uptake and utilization
	Biochemical factors	• Enzymes: Nitrate reductase (NR), phosphatase (P), pyruvate kinase (K), phytic phosphate (P) etc. • Metallothioneine (trace elements). • Root exudtaes (citrate, malic, transacconitic acid etc.)

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External factors	Fertilizers	• Source • Time/method of application • Interaction among nutrients • Nutrient losses
	Climate	• Soil moisture • Temperature
	Elements	• Toxicities: Acidic soils (Al, Mn, pH), saline (Na, Mg, Cl, SO_4) and alkaline (Na, CO_3) soils. • Deficiencies (N, P, K and micronutrients)
	Others	• Arbusculla rmychorhyzae and other soil microbes. • Control of weeds, insects and diseases • Incorporate crop residue, cover crops and crop rotation

Strategies to enhance nutrient use efficiency:

Nutrient expert based nutrient management

Use of fertilizers at the right rate, right time and at the right place.

Integrated nutrient management (INM)

Integrated nutrient management is regarded as the combined employment of conventional nutrient sources *viz.*, crop residues, organic manures, use of microorganisms for the N fixation as well as a chemical source of fertilizers (Olesen *et al.*, 2004). Utilization of all possible interactions among the aforesaid source of fertilizers is crucial to uphold soil quality and to perk up NUE (Aulakh and Malhi, 2004).

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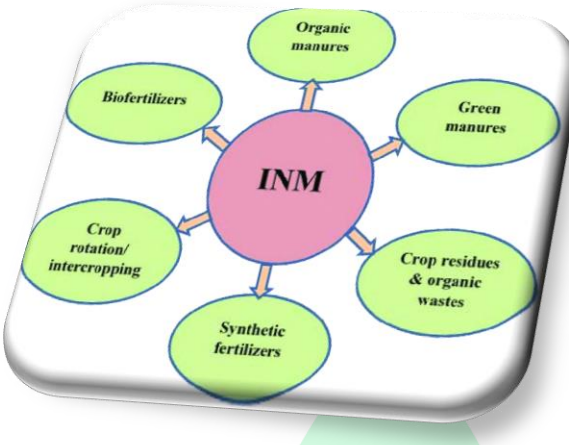
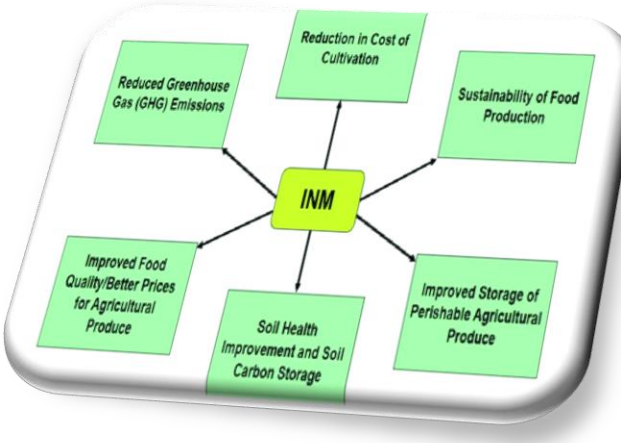


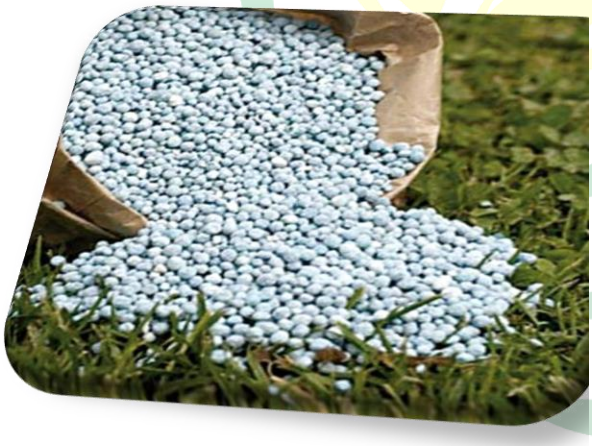
Components of INM



Benefits of INM approach

Use of modified fertilizers and nitrification inhibitors

Use of modified (apart from conventional) forms of fertilizers can recover NUE either by tumbling the losses associated or by slowly releasing the necessary nutrient at a constant rate to supply nutrients like slow-release fertilizers eg. Neem coated urea, sulphur coated urea, prilled urea and polymer -coated urea. They also reduce the loss of nutrients in the production system.



Neem coated urea

Polymer coated urea

Resource conservation technologies

Zero tillage (ZT) and permanent bed planting with appropriate residue management is fetching more popularity in many areas across the globe. Long-term adaptation is noticed to improve soil health.

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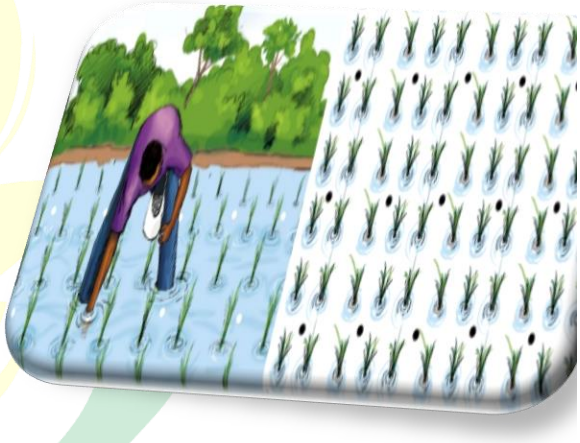
Proper crop rotations

Growing multiple crops on the same piece of land in a particular cropping year is termed crop rotation (Gan *et al.,* 2003). The selection of suitable crop combinations can be helpful to improve NUE.

The improved method of fertilizer application

Amongst the methods of fertilizer application, deep placement, use of super granules and foliar spray of N fertilizer can augment the recovery of applied N fertilizer. Use of modified form of N fertilizer (urea super-granules) and deep placement of urea-based fertilizers was reported to boost NUE. Broadcasting and deep placement of urea super granules in rice can improve nitrogen recovery from the soil.

Foliar application



Deep placement of urea super granules

Residue management

Plant residues are principal sources as well as sinks for the carbon and nitrogen cycle. Crop residues provide nitrogen to the plants for a longer duration at first by converting it into inorganic form and then mineralize it at later stages of the crop when N demand of crop is substantial.

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Green manuring

Many legume crops and also non -legume crops act as a source of nutrients and can be used in integrated nutrient management programmes to improve soil health and NUE.

Dhaincha (Sesbania aculeata)

Sunnhemp

Management of biological stresses

The incidence of biotic stress significantly affects the capability of crop plants to use nutrients and other resources. Good management of diseases, insects and weeds is very critical for better NUE.

Precision farming

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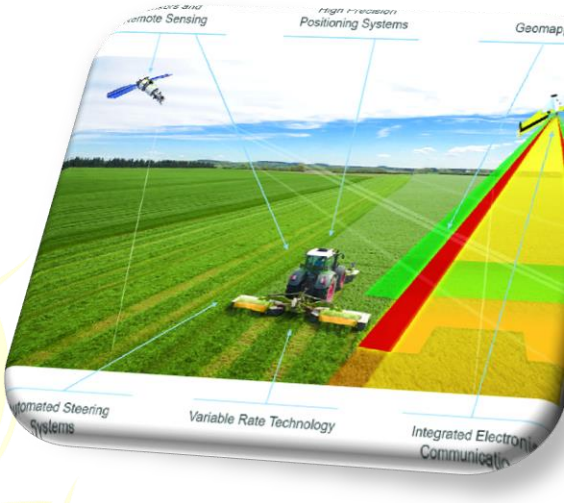
Precision farming sensor-based farm input management system which aims at the use of technologies and principles to identify, analyse and manage spatial and temporal variability associated with all aspects of agricultural production within fields for maximum profitability, sustainability, enhancing crop performance.



Development of improved varieties

Superior varieties can be chosen based on their uptake efficiency, translocation efficiency and can be used for the development of improved varieties to enhance NUE.

Conclusion

Extensive use of fertilizers is weakening the health of the environment, contaminating plant foods, pessimistically affecting biophysical properties of soil and mounting the cost of production. Therefore, various strategies like the implementation of INM, better methods of fertilizer application, integration of green manuring, fertilizer management strategies, etc. can be helpful to improve NUE.

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