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Nutrient Use Efficiency: An Overview

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Introduction

Invariably, many cultivated soils of the world are scarce in one or more of the essential nutrients required supporting vigorous plants. Estimates of overall efficiency of applied fertilizer have been reported to be around or lesser than 50% for N, less than 10% for P, and about 40% for K (Baligar *et al*., 2001). Plants that are capable in absorption and utilization of nutrients prominently enhance the efficiency of applied fertilizers, decreasing cost of inputs, and avoiding losses of nutrients to ecosystems. To increase fertilizer use efficiency (FUE) and to reduce its negative influence on the atmosphere has been an important point in the world for a long time. It can be particularly affected by fertilizer management as well as by soil and irrigation Management. There is increased demand for fertilizer nutrients to meet the global demand for food, However there are inadequate fertilizer resources available and rising public concern related to nutrient use side effects. This has led to calls for NUE to be improved, but not at the expense of decreased crop productivity. Nutrient use efficiency (NUE) depends on the plant's capacity to take up nutrients efficiently from the soil, but also depends on inner transport, storage and remobilization of nutrients.

What is NUE/FUE?

Nutrient use efficiency (NUE) may be defined as yield per unit fertilizer input or in terms of recovery of applied fertilizer. Nutrient use efficiency (NUE) is a critically important concept in the evaluation of crop production systems.

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Common NUE and their applications (after Dobermann, 2007):

Term	Calculation	Typical use
Partial factor productivity	PFP = Y/F	As long term indicator of trends.
Agronomic efficiency*	AE = $(Y-Y_0)/F$	It is use as short-term indicator of the impact of applied nutrients on productivity.
Partial nutrient balance	PNB = U_H/F	As long-term indicator of trends, mostly used when combined with soil fertility information.
Apparent recovery efficiency by difference**	RE = $(U-U_0)/F$	As an indicator of the potential nutrient loss from the cropping system and to access the efficiency of management practices.
Internal utilization efficiency	IE = Y/U	To evaluate genotypes in breeding programs; values of 30-90 are common for N in cereals and 55-65 considered optimum.
Physiological efficiency**	PE = $(Y-Y_0)/(U-U_0)$	Research evaluating NUE among cultivars and other cultural practices, values of 40-60 are common.

*Y = yield of harvested portion of crop with nutrient applied; Y_0 = yield with not nutrient applied; F = amount of nutrient applied; U_H = nutrient content of harvested portion of the crop; U= total nutrient uptake in aboveground crop biomass with nutrient applied; U_0 = nutrient uptake in aboveground crop biomass with no nutrient applied; Units are not shown in the table since the expressions are ratios on a mass basis and are therefore unit less in their standard form. P and K can either be expressed on an elemental basis (most common in scientific literature) or on an oxide basis as P_2O_5 or K_2O (most common within industry). **Short-term omission plots often lead to an underestimation of the long-term AE, RE, or PE due to residual effects of nutrient application.

How to increase FUE: -

The objective of nutrient use is to increase the overall performance of cropping systems by supplying economically optimal nutrients to the crop. For increasing NUE approaches defines below-

1) Scientific nutrient management:

Appropriate nutrient management in cropping systems should purpose to supply suitable fertilizers based on the demand of the crops and apply in this method that reduce loss and maximize the use efficiency.

a) Right Rate - Soil testing is most important technique available for determining the nutrient supplying capacity of the soil, but to be useful for making appropriate fertilizer recommendations , good calibration data is also necessary (IPNI, 2012b).

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b) Right Time - It is the interrelated to site specific nutrient management (SSNM). Greater synchronization between crop demand and nutrient supply is necessary to improve nutrient use efficiency, especially for N (Giller *et al*., 2004). Split applications of N during the growing season, rather than a single, large application prior to planting, are known to be effective in increasing N use efficiency.

c) Right Place - Fertilizer application method is influenced use efficiency. Mainly two methods are used for fertilizer application, before and after planting. Determining of right placement is very important for deciding the rate of application.

2) Integrated Nutrient Management (INM):

INM involves optimum use of indigenous nutrient components i.e. crop residues, organic manure, biological N fixation as well as chemical fertilizer and their balancing interactions to rises N and P recovery. The appropriate understanding and exploitation of these positive interactions among the plant nutrient is keys for increasing returns to the farmers in terms of yield as well as soil quality and NUE of applied N (Aulakh and Malhi, 2004).

3) Use of modified fertilizers:

a) Use of slow release fertilizers - A range of slow release fertilizers is now marketed which have the potential to reduce various N losses and improve NUE (Giller *et al*., 2004).

b) Use of nitrification inhibitors - Addition of nitrification inhibitors can check conversion of ammonium-N into nitrate-N and ensure higher concentration of ammoniacal form of nitrogen in soil medium, to increase NUE and crop yield (Shivay *et al*., 2001). Nitrogen stabilizers (e.g., nitrapyrin, DCD [dicyandiamide], NBPT [n-butyl- thiophosphoric triamide]) inhibit nitrification or urease activity, there by slowing the conversion of the fertilizer to nitrate.

4) Use of organic and green manures.

5) Use of conservation tillage for proper crop residue management.

6) Reducing losses of nutrients.

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