



## NITROGEN USE EFFICIENCY THROUGH AGRONOMIC MANAGEMENT

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Nitrogen (N) fertilization enhanced food production in developing countries especially after the introduction of high yielding and fertilizer responsive crop varieties. However, excess use of chemical N fertilizer may negatively affect surface water, as well as groundwater, and the atmosphere. The average nitrogen-use efficiency (NUE), especially through chemical fertilizers such as urea, in India ranges from 20 to 50% for rice. Hence, N application and crop management must be fine-tuned in order to maximize system-level NUE. NUE depends on several agronomic factors including tillage, time of sowing, appropriate crop variety, proper planting or seeding, sufficient irrigation, weed management, pest/disease management, and balanced and proper nutrient use.

**Agronomic management:** The agronomic approaches to improving the NUE includes promoting higher N use efficient genotypes, mode and rate of application of N, efficient crop rotation/sequence, use of organic manures, green manures, and other legume in cropping system etc.

**Shifting toward nitrogen-intensive crops:** Cropping systems with differential requirement and contribution to modifying the rhizosphere by different crops provide newer challenge as well as opportunity for management to achieve higher nutrient-use efficiency. For example-pigeonpea substitution for rice during monsoon season in rice-wheat cropping system, improves the wheat yield and total N uptake.



**Efficient crop rotations:** Effective rotations of leguminous crops can also contribute to an increase in the NUE and reduce  $\text{NO}_3\text{-N}$  leaching losses. To take advantage of the higher N fertilizer equivalence of a leguminous crop, this should be rotated with a crop that has a higher NUE. This kind of rotation increases the N recovery from the crop residue, increase the NUE and reduce  $\text{NO}_3\text{-N}$  leaching.



**Plant population:** Sub-optimal plant population is one factor that reduces crop yields in India more than any other factor. Lower seed rates associated with wider spacing and fewer seedlings per hill in the case of rice and seedling mortality due to diseases and pests are the major factors that affect plant population in other crops. In rice transplanting two seedlings is advantageous from the viewpoint of grain yield as well as partial factor productivity of N. Increasing seed rate from 100 to 125  $\text{kg}\cdot\text{ha}^{-1}$  increases rice yield by 240  $\text{kg}\cdot\text{ha}^{-1}$  and partial factor productivity (PFPn) by 2%. Further increase in seed rate, however, reduces grain yield and PFPn. A large volume of data exists on seed rate, spacing, thinning etc. on most crops in India but it has not been linked with NUE.

**Water management:** Water management involving proper irrigation scheduling (irrigated areas) and the NUE and water use efficiency (WUE) are inter-dependent. In general, both



decrease as the levels of N and water application increase. The goal, therefore, has to be to find a combination of N and irrigation level that gives the highest yield. Irrigation scheduling is important for improving NUE. The goal is to supply enough water to optimize yield while avoiding excess irrigation which can increase costs and leach N below the root zone.

### EFFICIENT N MANAGEMENT STRATEGIES

**Timely N application:** Time of N fertilizer application is one of the major constraints for low NUE. It is basically due to several factors such as crop growth stage, amount and availability of water within the rooting depth of any crop and other macro and micro environmental conditions. Timely N application is one agronomic technique which has helped considerably in increasing the NUE. Improved timing of N fertilizer application leads to higher efficiency by minimizing N losses and matching N availability to crop plant requirement at critical growth stages i.e. time of N fertilization to provide adequate amount of N when plants are actively growing and using N rapidly.

**Rate of N application:** Rates of N fertilization influence total dry matter production of crops, therefore affecting the nutrient demand of crops. Generally, increasing the rates of application of N reduce the overall NUE, probably due to greater N loss from soil system. A combination of soil testing, fertilizer N experiences of the producer and predictable N requirements are the best management tools available for farmers to determine optimum N rates. Optimal rates of N fertilizer depend mainly on the total N demand of crops, the amount of available N from sources other than applied N, and the efficiency of fertilization in order to increase plant available N. In order to improve N fertilizer recommendations, the prediction of the total N demand as well as the prediction of the fertilizer efficiency is essential.

### METHOD OF N APPLICATION

**Split application:** Split application is a well proven and well accepted method of N fertilizer application for increasing NUE in most of irrigated crops and generally split 2 to 3 equal doses is recommended. Split application of N is highly desirable since crop plants take up very small amounts of N  $\text{ha}^{-1}\text{day}^{-1}$ . The rate of the first N application either before or soon after crop establishment is determined from pre-existing information. Split applications of N during the growing season, rather than a single, large application prior to planting, are known to be effective in increasing NUE.

**Band placement:** Band-placed fertilizer N leads to a reduced N immobilization and creates a micro-environment and is as effective as deep placement of Urea Super Granules (USG) in reducing volatilization losses and improving grain yield. Advantages of band placement of fertilizer N at a depth of 10-15 cm is that, under dry land conditions, surface placed fertilizer N will need to be leached first into the rooting zone before it becomes accessible to the roots. By placing the fertilizer N 10 cm into the moist soil, fertilizer N urea use efficiency increased significantly.

**Deep placement:** Deep point placement of urea fertilizer is probably the most effective application method in reducing N loss except in soils with high percolation rates. Deep placement of USG has greater benefit over surface split application on soils with moderate to heavy texture, low permeability and percolation rate, and high cation exchange capacity and pH. Deep point placement (5-10 cm depth) in anaerobic soil layer can limit the concentration of N in flood water and in the surface oxidised layer, decreases N losses. The placement technology, if adopted by the farmers of the potential low land areas.

**Foliar N Application:** Foliar application of urea or ammonium  $\text{NO}_3$ -solutions since, unlike soil applied N, foliar applied N is less subject to surface runoff, microbial immobilization, volatilization, and denitrification before being absorbed by the plant. The rationale for the use of foliar fertilizers include: i) when soil conditions limit availability of soil applied nutrients; ii) in conditions when high loss rates of soil applied nutrients may occur; iii) when the stage of plant growth, the internal plant demand and the environment conditions interact to limit delivery of nutrients to critical plant organs.

**Balanced and integrated plant nutrient supply (IPNS):** IPNS is an approach, which involves judicious, combined use of fertilizers, biofertilizers, organic manures (FYM, compost, vermicompost, biogas slurry, green manures, crop residues) and growing of legumes in cropping system. IPNS involves monitoring all pathways of flow of plant nutrients in agricultural production systems to maximize profit so that farming as a profession can be sustained, which is the only way to produce food. Legumes are the most important component of IPNS. They may be grown as a green manure, grain crop, or as a dual purpose crop (grain as well as green manure) in cropping systems.

**Site-Specific N Management:** The site specific N management (SSNM) provides an approach for need based 'feeding' of crops with nutrient. There are three basic approaches for site specific N management such as 1) Site specific N recommendation



based on grid soil sampling, Residual soil nitrate N values, N availability maps and N fertilizer recommendation maps, 2) Second approach is to develop site specific optional N rate recommendation based on condition-specific N response curve and 3) Third approach is to monitor N status by canopy reflectance of light and leaf colour chart (LCC).

**Leaf colour chart:** The leaf color chart (LCC) is an innovative cost effective tool for real-time or crop-need-based N management in rice, maize and wheat. LCC is a visual and subjective indicator of

plant nitrogen deficiency and is an inexpensive, easy to use and simple alternative to chlorophyll meter /SPAD meter (soil plant analysis development). It measures leaf color intensity that is related to leaf nitrogen content based on chlorophyll content in the leaves at different growth stages. LCC is an ideal tool to optimize N use in rice/maize at high yield levels, irrespective of the source of N applied, viz., organic manure, biologically fixed N, or chemical fertilizers.

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