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Approaches to mitigating N loss in rice cultivation: the coastal district of Odisha

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Baishnab Charan Muduli, Rhea Samantaray
Ph.D. Scholar ICAR-National Rice Research Institute, Cuttack, Odisha, India

INTRODUCTION

Rice is an important cereal, providing more than half of the world's population (Fageria et al. 2011). Lowland rice, also known as flooded rice, accounts for approximately 76% of world rice production. Nitrogen is one of the most limiting nutrients for rice production, accounting for about 37% of total fertilizer-N consumption in India. In most agricultural production regions, the N recovery efficiency of rice with low soil levels is 50% of nutrient uptake. However, 60-70% of applied N is lost from the rice ecosystem as reactive N. Odisha is one of the eastern coastal states of India that experiences frequent natural disasters like floods/cyclones due to its unique geo-climatic conditions. While nitrogen is an essential element for life on Earth, molecular nitrogen is relatively unreactive and must be converted to other chemical forms through nitrogen fixation before it can be used for growth. Common reactive nitrogen Species such as ammonia volatilization (NH3), nitrous oxide (N2O) emission, nitrate leaching (NO3), nitric oxide (NO) and nitrogen dioxide (NO2) due to various processes in the lowland rice ecosystem of Odisha Costal region. Improving nitrogen use efficiency through better nitrogen management is more important than ever to ensure food security and environmental sustainability. The optimal level, timing and strategy for N application are critical factors for an effective lowland N management approach.

Loss of Reactive Nitrogen: Sources and losses of N in the low land rice through different pathways such NO_3^- leaching, NH_3 volatilisation, N_2O emission and surface runoff. N input in rice fields from fertilizer, precipitation, and biological fixation was 79.5, 8.8, and 43.0 kg N ha^{-1}(Katayanagi et al.2013).

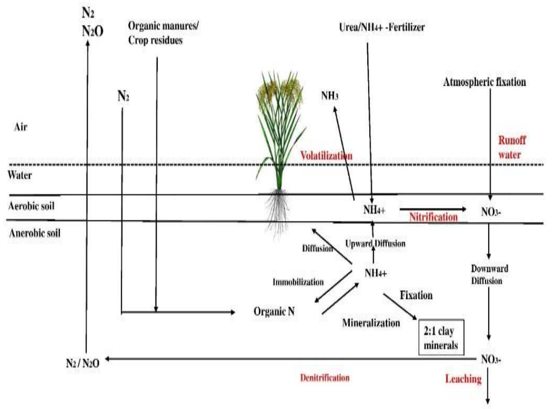

Figure-1Various pathways of N loss in low land rice.

Strategies to enhances NUE in rice land

Nitrogen management plays an essential role for long-term and successful rice cultivation in India. Nitrogen recovery can be improved through the application of locally and scientifically available N management methods to ensure effective utilisation of agricultural inputs (chemical fertilizers, organic inputs, environmental inputs, and crops) that will increase beneficial use of N in crops while reducing the number of losses. Several strategies have been developed to improve urea and nitrogen efficiency, including optimum timing, rate, place, improved fertilizer forms, and the use of nitrification and urease inhibitors (Ladha et al. 2005). Several methods for enhancing NUE based on the above-mentioned strategy will be addressed below:

Figure-2 Nitrogen management for low land rice.

Site Specific Nutrient Management (SSNM)

The synchronisation of N supply with plant needs is the most effective management practice for maximising plant absorption and minimising losses. Site-specific N management requires quantitative knowledge of crop nutrient requirements and projected indigenous nutrient supply, and it may be used to improve fertilizer recovery efficiency. The main objective is to maximize the ratio of N supply and demand (Giller et al. 2004). The International Rice Research Institute (IRRI) developed site-specific N management (SSNM) strategies such as real-time N management (RTNM) and fixed-time adjustable-dose N management (FTNM) to improve the fertiliser NUE of irrigated rice. Leaf N concentration may be assessed non-destructively using a soil plant analysis development (SPAD) chlorophyll metre or leaf colour chart (LCC), as well as nutrient expert-based N management and sensor-based technologies.

1 Leaf Colour Chart (LCC)

Research conducted in various parts of Asia found that the use of LCC could prevent the use of up to 25% of the nitrogen used in rice cultivation. A five-panel adapted leaf colour chart (CLCC) developed by ICAR-NRRI was evaluated at the station and in farm fields, and the results showed that following CLCC recommendations on RDF application and farm use could lead to yield benefits of 0.5-0.7 t ha- 1 and 0.5-1.0 t ha-1 at the same level of N application (Nayak et al., 2017).

How to use the LCC in rice field

Select at least 10 plants of rice that are disease-free. Select the top-most leaf that has fully expanded, compare the colour to the LCC's colour panels, and do not separate or harm the leaf. Measure the colour of the leaf under your body's shade. Determine the selected leaves average LCC reading.

2 Chlorophyll meter (SPAD)

The SPAD - chlorophyll metre measures the relative chlorophyll content of leaves. Because the majority of plant N is found in chloroplasts and therefore is directly connected to leaf chlorophyll concentration, crop N status may be assessed using a chlorophyll metre (Olesen et al., 2004). The SPAD evaluation of 35 or 37 is considered the crucial threshold for extra N top dressing in low land rice (Ghosh et al. 2020). Compare to traditional local N management practices, SPAD meter based SSNM in rice crop can increases yield.

Figure-4 Author measure chlorophyll content in leaf using SPAD meter in different stages of Rice.

Measuring SPAD values in the field

To measure SPAD, a young, fully expanded leaf of the plant is used, data is obtained on one side of the midrib of the leaf blade, and the average of 10-15 measurements per field or plot is used as the measured SPAD value. If SPAD values fall below thresholds, N fertilizer should be applied immediately to prevent yield loss.

Nutrient expert-based N management

Nutrient Expert, an evolving nitrogen management assessment tool, manages fertilizers at the **right time, place and rate** (variable rate application) based on crop requirements. It facilitates more efficient use of inputs, saves money on fertilizers and guarantees sustainable use of natural resources. Stand reflectance sensors to help with crop needs N has a lighter colour, smaller dimensions and an optical sensor that instantly measures plant health and vitality using NDVI values. It reflects light differently than a crop that has enough N.

Table-1: NUE enhances different Nitrogen management practices

Conclusion & future prospects

Addressing the loss of reactive nitrogen in lowland rice cultivation in coastal Odisha is essential to increase NUE, minimize environmental impact and ensure long-term production. Nitrogen fertilizers are rapidly lost from the soil system for many reasons; so to improve nitrogen uptake by crops, nitrogen supply should be synchronized with nitrogen demand. Continued research and innovation is needed to overcome reactive nitrogen depletion in lowland rice in the future. This consists of developing better cultivars with a higher NUE value, experimenting with new fertilizer formulations or delivery methods, and increasing the accuracy of technological advances in agriculture for better nitrogen management. In addition, increasing farmer knowledge and training on best practices for N use management and environmental protection would be essential for greater adoption. It is possible to reduce N by using the recommended techniques and adopting future improvements in the state of Odisha.

Reference

Fageria NK, Dos Santos AB, Coelho AM. Growth, yield and yield components of lowland rice as influenced by ammonium sulfate and urea fertilization. Journal of Plant Nutrition. 2011 Jan 20;34(3):371-86.

Ghosh M, Swain DK, Jha MK, Tewari VK, Bohra A. Optimizing chlorophyll meter (SPAD) reading to allow efficient nitrogen use in rice and wheat under rice-wheat cropping system in eastern India. Plant Production Science. 2020 Jul 2;23(3):270-85.

Giller KE, Chalk P, Dobermann A, Hammond L, Heffer P, Ladha JK, Nyamudeza P, Maene L, Ssali H, Freney J. Emerging technologies to increase the efficiency of use of fertilizer Olesen JE, Sørensen P, Thomsen IK, Eriksen J, Thomsen AG, Berntsen J. Integrated nitrogen input systems in Denmark. Agriculture and the nitrogen cycle: Assessing the impacts of fertilizer use on food production and the environment. 2004 Sep 15; 65:129-40.

Katayanagi N, Ono K, Fumoto T, Mano M, Miyata A, Hayashi K. Validation of the DNDC-Rice model to discover problems in evaluating the nitrogen balance at a paddy-field scale for single-cropping of rice. Nutrient cycling in agroecosystems. 2013 Mar; 95:255-68.

Ladha JK, Pathak H, Krupnik TJ, Six J, van Kessel C. Efficiency of fertilizer nitrogen in cereal production: retrospects and prospects. Advances in agronomy. 2005 Jan 1; 87:85-156.

NayakAK, MohantyS, Chatterjee D, Guru PK, Lal B, Shahid M, Tripathi R, Gautam P, Kumar A, Bhattacharyya P, PandaBBand Kumar U (2017). Placement ofUrea Briquettes in Lowland Rice: An Environment friendlyTechnology for Enhancing Yield and Nitrogen Use Efficiency. NRRI Research Bulletin No.12ICAR-National Rice Research Institute, Cuttack, Odisha 753006, India. pp. 1-26

Olesen JE, Sørensen P, Thomsen IK, Eriksen J, Thomsen AG, Berntsen J. Integrated nitrogen input systems in Denmark. Agriculture and the nitrogen cycle: Assessing the impacts of fertilizer use on food production and the environment. 2004 Sep 15; 65:129-40.

Figure-3 Using the LCC in rice field

Figure-4 Author measure chlorophyll content in leaf using SPAD meter in different stages of Rice

Figure-5 Using Green Seeker Handheld Sensor

Management practice	NUE and Farmers benefits
Site-specific N management (SSNM)	SNM could enhance NUE from 31 to 40% and increased grain yie by 5% compared with farmers' N practices
Leaf color chart (LCC) based N management	The LCC-based N approach in rice can reduce N application by 1 30 kg per hectare without affecting rice grain yield, unlike t traditional fixed-time N application method.
Chlorophyll meter-based N management	Using SPAD values to improve nutrient use efficiency (NUE) lowland rice cultivation. SPAD chlorophyll-based nitrog management methods improve nitrogen use efficiency by 58.5% a nitrogen recovery efficiency by 32.2% compared to fixed-tin nitrogen management practices. Using the SPAD value to determi the amount of nitrogen fertilizers for rice cultivation can help save lot of nitrogen (33.3%) compared to the traditional method witho affecting the amount of rice produced.
Nitrification inhibitors	Increased NUE in rice by 16 and 29% in 2012 and 2013, respective when 180 kg N ha−1 was applied.
Crop rotation and diversification	Improve soil N fixation and nitrogen cycling. Legumes may atmospheric nitrogen, reducing the demand for fertilizers containi nitrogen in succeeding crops of rice.
Azolla	Compared to farmers using certain nitrogen treatments, the use of Azolla cover with a 15% reduction in nitrogen increased appare nitrogen by 46.5% in lowland rice cultivation. Using Azolla cov with 30% nitrogen reduction increased apparent nitrogen by 39.1%
Integrated nutrient management	Urea+ organic manure treatment reduced N2O emission by 11–24 than that of the urea treatment.