DIFFERENT SOURCES OF NITROGENFOR RICEPROUCTION: A REVIEW

ABSTRACT

Rice is the most important agricultural product in the country's economy. Nitrogen fertilization is a fundamental agronomic technique influencing rice crop yield and quality.Under the R-W system, crop yield declines and soil fertility gradually decreases when artificial N fertilizers are used without organic sources. Not only is the right fertilizer dosage critical for achieving the best results, but the timely application of nitrogen is also essential. Inorganic Nitrogen sources(Neem Coated Urea, Prilled Urea, Briquette Urea, Nano Urea) known to show quick results and organic Nitrogen sources (Farm Yard Manure, Poultry manure, Vermicompost, Green manure, Jeevamrutha, Biofertilizers)being slow degradable and ecofriendly combined use of these sources has shown good results.Nitrogen must be applied as much as possible during the early and mid-tillering stages to maximize the number of panicles and during the reproductive stage to produce the ideal number of spikelets per panicle and % of filled spikelets.

Keywords: Brown Manure, Nitrogen Use Efficiency, N fixation, Microbes

INTRODUCTION

A significant and widely grown food crop, rice (Oryza sativa L.) provides sustenance for over half of the world's population. Over 2 billion people in Asia alone rely on rice and its derivatives for 60–70% of their daily energy intake (UDHAYAKUMAR & RAMASAMY, 2016). 33 hybrid rice varieties and 78 inbred rice genotypes have been approved for use in commercial rice farming in Nepal (Kakshapati et al., 2022).5.13 million MT of rice was produced in 2022 with an average yield of 3.47 MT/ha on a total area of 1.48 million ha under rice cultivation. Of the total amount of cereal grains consumed (181 kg), the percentage of rice consumed annually per capita was 76% (137 kg)(MoALD, 2022). This implies that rice plays a major role in Nepal's food security. The most valuable agricultural product to the country's economy is rice. In terms of the agricultural gross domestic product (AGDP), rice accounts for 13%, while its part of the national GDP is 4%(MoALD, Agriculture Development Strategy (ADS) Joint Sector Review (JSR), 2023).

In Nepal, rice leads the way in terms of area covered, production, productivity, and preferences. In the fiscal year 2075–2076 B.S., rice contributed 15.35% to the country's gross domestic product (GDP) with an average productivity of 3.76 mt/h.According to data from the Ministry of Agriculture and Livestock

Development for the fiscal year 2077–2078 in Nepal, 76 lakh 21 thousand MT of rice was produced on 14 lakh 73 thousand hectares of land. The average productivity of rice is 3.81 MT per hectare (Agriculture diary, 2079).

Between 2000 and 2021, the amount of inorganic fertilizers used globally per hectare of crops increased from 82 to 112 kg. Fertilizer use per person stayed relatively stable at about 25 kilograms per capita over this period, despite a decline in consumption per value of production from 51 to 47 kilograms per thousand dollars(FAO, 2023). Unanimous application of chemical pesticides and fertilizers in the absence of organic sources caused the soil's health to gradually decline, endangering agricultural output (Devkota et al., 2019).

A significant amount of nitrogen (N) is needed for rice production, as it plays a crucial role. In addition, it is the mostscarce nutrient used in the cultivation of rice and experiences significant losses in the system when used as inorganic sources in puddled fields. Only 30–40% of the nitrogen applied is successfully used in irrigated paddy cultivation (Manikyam et al., 2020).Under the R–W system, crop yield decreases and soil fertility gradually declines when artificial N fertilizers are the only ones used without organic sources(Amanullah et al., 2020).

Rice loses 50-70 % of its applied nitrogen fertilizer due to a mismatch between demand and supply. This problem can be solved using two basic approaches. One is to control the timing of N use and other goal is to improve the ability of the rice root structure to fix its own nitrogen. Despite increased use of nitrogen, many farmers still use insufficient amounts due to lack of availability, financial constraints, poor crop response, or elevated risk. Over fifty percent of applied nitrogen is lost through de-nitrification, ammonia volatilization, leaching, and runoff. This context highlights the significance of biologically fixed Nitrogen(Papademetriou et al., 2000).

METHODOLOGY

This review is based on secondary sources of information. We gathered reports on the impact of nitrogen sources on rice growth and yield from various sources, including journal articles, research papers, books, and review articles and summarized key findings.

DISCUSSION

The three most crucial nutrients for increasing crop yield are potassium, phosphorus, and nitrogen. Growth and metabolic processes require nitrogen. Typically, farm manure and the chemical fertilizer urea are used to supply nitrogen (Ranjan Sarangi & Sadangi, 2015)

Nitrogen(N)

Nitrogen (N) is the most significant and vital plant nutrient, and it will significantly impact crop yield. For all non-legume crops, N is necessary in all types of soil. Natural sources of nitrogen include soil minerals, organic matter in the soil, manure, rice straw, and water from irrigation or rainfall. Many crop wastes are currently not returning to the land because they are used so extensively as fuel and animal feed. Only the application of organic matter, such as manures, can replace soil organic matter in the near term. However, when applied alone, organic manures are unlikely to meet the needs of high-yielding rice cultivars due to their comparatively low nutrient content (Sharada & Sujathamma, 2018).

Due to the numerous chemical and biological processes that regulate Nitrogen accessibility, which are in turn greatly impacted by soil and climatic conditions, Nitrogen is the most complex element in terms of handling and application (De Menezes Santos et al., 2020).

Numerous methods exist for nitrogen to influence production. Firstly, nitrogen increases the number and volume of cells at the cellular level. Secondly, nitrogen enhances the pace and efficiency of photosynthetic processes at the leaf level. Increased N % in plant tissues at higher N supply is evidence that fertilizer N also raises proteins, a component of the plants' metabolism(D. Singh & Kumar, 2014).

The crop growth stage, cropping site, and year all have a substantial impact on the Nitrogen uptake rate under suboptimal Nitrogen nutrition. On the other hand, crop N uptake, which is governed by a number of internal plant systems, directly influences crop growth rate, dry matter (DM) accumulation, and leaf area (LA) expansion under conditions of abundant N availability(Ata-Ul-Karim et al., 2017).

Thus the primary agronomic technique that influences rice crop yield and quality is nitrogen fertilization, which must be applied as much as possible during the early and mid-tillering stages to maximize the number of panicles and during the reproductive stage to produce the ideal number of spikelets per panicle and % of filled spikelets(Abd El-Megeed& El-Habet, 2020).Unbalanced fertilizer application and nitrogen mining are the result of falling agricultural yields and declining soil fertility (Rahman & Ranamukhaarachchi, 2002).

Fertilizer efficiency can be improved through two methods: matching nutrient supply to crop need (best time for application) and adopting enhanced techniques like controlled-release and deep placement. Organic fertilizers promote long-term fertility of soil, improve chemical fertilizer efficiency, and increase farm profitability(Pingali et al., 1997)

Applying nitrogen in split doses as opposed to one can minimize groundwater contamination and possible nitrogen losses by as much as 30%. Not only is the right fertilizer dosage crucial for achieving the best results, but timely application of the fertilizer is also essential(El-Habashy et al., 2013).For modern rice types to yield more grain at medium to high land elevations, N should be applied in three splits: during planting, tillering, and panicle initiation(Kamruzzaman et al., 2014).The increased spikelets per panicle, 1000 grain weight, ripened grain %, and N uptake can all be attributed to the altered splits, which may lead to a decrease in the amount of nitrogen fertilizer applied(Hameed et al., 2019).

Table 1: Symptoms of excess and deficiency of Nitrogen

S.N	N deficiency symptoms	S.N	Excessive N symptoms
1.	Stunted growth and Discoloration	1.	Soil acidification
2.	Death of leaf from top to bottom	2.	Chalky rice and poor in observation, eating and cooking quality
3.	Young leaves appear thin, short and rigid and in extreme case die	3.	Increases plant tissue susceptibility and rice canopy density, leading to disease incidence
4.	Roots becomes slender and lengthy with decreased numbers	4.	Rice blast
5.	Decrease in plant height and numbers of tillers	5.	Low NUE (Nitrogen Use Efficiency)
6.	Decrease in grain numbers and hence reduced yield	6.	Unfilled Panicles or partially filled panicles

Source: (Shrestha et al., 2022)

Table 2: Nitrogen % of different nutrient sources

Name of Nutrients	Nutrient content (%)		
	Nitrogen (N)	Phosphoric acid (P2O5)	Potash (K2O)
Urea	46		
Diammonium Phosphate (DAP)	18	46	
Single Super phosphate (SSP)		16	
Farmyard manure (FYM) (Dry weight basis)	1	0.5	1
Vermicompost	1.5	0.5	1
Green Manure			
1. Dhaincha (*Sesbania spp*)	1.48	0.29	2.04
2. Asuro (*Adhatoda vasica)*	4.3	0.88	4.49
3. Banmara (*Eupatorium antidysentrica*)	2.91	0.35	2.68
Jeevamrutha	1.05	0.122	0.081
Cow dung	0.70	0.285	0.231
Cow urine	1.67	0.112	2.544
Pulse floor	1.47	0.622	0.910

Source: (Mahanta & Dhar, 2021),(Agriculture and Livestock dairy, 2080), (Prasad Vista et al., 2022)

1. **Inorganic Sources of N**

Plants require either NH_4^+ or NO_3^- to absorb and utilize N from soil so Urea and ammonium nitrate are widely used as Nitrogenous fertilizers in traditional farming systems. Organic Nitrogen sources usually hold one-tenth to one-hundredth of the total N found in urea(Hue & Silva, 2000).Various inorganic sources of Nitrogen are:

a. Urea

i. Neem Coated Urea

It has been shown that neem coated urea (NCU), an indigenous nitrification inhibitor, improves rice growth, yield, uptake, and usage efficiency of administered N fertilizer(Kumar Meena et al., 2019).

ii. Prilled Urea

A common fertilizer with a high nitrogen content (46%) for agricultural output is prilled urea (PU). About 25–30% of PU is effective in rice fields; the remaining 70–75 % is lost for a variety of reasons after application(Al et al., 2013).

A significant amount of nitrogen (N) is lost when urea is broadcasted on crop fields due to leaching, runoff, evaporation, volatilization (atmospheric), and denitrification. More nitrogen is transformed into nitrates, which can contaminate groundwater because they are mobile in the soil (Akter et al., 2015).

iii. Briquette Urea

USGs positioned deeply in the decreased zone stop NH from quickly converting to NO and causing losses. As a result, compared to conventional urea fertilizer, N is available to the plant for a longer period of time, which leads to notable increases in N uptake and grain yield. According to IFDC guidelines, urea briquettes or pellets are typically manually distributed at a soil depth of 7 to 10 cm at a rate of one USG at the center of each four rice hill (Nayak et al., n.d.).

With the deep placement method, huge fertilizer granules or briquettes are buried 8–10 cm below the surface of the soil, providing a gradual and consistent delivery of nitrogen over the rice's growth period. Using urea deep placement (UDP) instead of the traditional broadcast application of prilled urea can reduce nitrogen losses by as much as 50% (Sharna et al., 2021).

In comparison to Prilled urea using the conventional split application, the single application of 150 kg ha-1 of nitrogen from PCU and UB was similarly productive. This suggests labor savings under the novel nitrogen management strategy (Marahatta, 2022).

The yield of BR22 rice was positively impacted by the application of PU, USG, and NPK briquettes. T3 (104 kg N ha-1 from USG) produced the highest grain yield, 3.93 t ha-1, which was statistically comparable to T5 (120 kg N ha-1 from PU), T7 (78 kg N ha-1 from USG), and T8 (78 kg N from NPK briquette), but noticeably better than all other treatments (Naznin et al., 2013).

Maximum grain and straw yields of 76.20 q ha-1 and 99.06 q ha-1, respectively, were recorded under the treatment receiving urea briquette (150 kg N ha-1) that are deep placed using UB applicator (T10) among the various urea application methods. This is significantly higher than the treatment in which prilled urea was broadcast and under the control (Deep et al., 2020).

iv. NanoUrea

Nanomaterials typically range in size from 1 to 100 nm. Nano fertilizers offer numerous benefits, including increased nutrient use efficiency, reduced reliance on chemical fertilizers, increased crop stress tolerance, eco-friendliness, increased plant nutrient mobilization (30-35%), and 18-54% increase in yields of crops. A half bottle of nano urea used more efficiently can effectively save up to one bag of urea. Spray 2 to 4 ml of nano urea liquid in 1 litre of clean water on crop leaves during tillering and one week before flowering(Kantwa& Yadav, 2022).

The research found that using urea(50%) in half dose with half the recommended rate of Nano Urea(50%) resulted in the highest plant height (104.7 cm), number of tillers (348), Leaf Area Index (5.73), and yield attributes such as filled grains per panicle (165.9), grain yield (7056 kg ha-1), and straw yield (8342 kg ha-1)(Kumar Midde et al., 2022). The experiment found that using 50% RDN (75 kg N) through urea (basal only) and foliar nano urea sprays at 20th, 40th, and 60th DAT resulted in enhanced plant height, LAI, and yield. (A. S. et al., 2023).

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2. <u>Organic sources of N</u>

Farmers are becoming more aware of the benefits of using an organic farming system to produce their crops because of the rising costs of chemical fertilizers, the reduction of soil fertility, organic matter and secondary and micronutrients, the health and environmental risks associated with the use of pesticides, and the anticipated high prices for crops grown organically(Yadav et al., 2019).Various organic sources of Nitrogen are:

i. Farmyard Manures

There are several publications on the impact of manure on soil qualities, and it has long been thought of as a beneficial soil amendment. A variety of animal manures have been utilized to provide crops with nutrients(Järvan et al., 2017).Applying FYM has been shown to enhance crop growth by giving plants nutrients, especially micronutrients, and by enhancing the physical, chemical, and biological characteristics of the soil(Tadesse et al., 2013).

Although FYM has long been known as the best organic fertilizer to improve soil quality, utilizing organic manure alone will not increase crop yields because of their limited availability. Thus, it has been proposed that the best way to preserve a healthy and sustainable soil system while boosting crop output is through integrated nutrient management, which uses both organic manures and inorganic fertilizers concurrently(Redda Gebremedhin & Tesfay, 2015).

In terms of all yield parameters, including panicles per m2, panicle length, grains per panicle, test weight (g), and grain and straw yield, treatment T6 (50%RDF+50%FYM) performed the best (Tiwari, 2017).A greater grain yield (344.69 kg ha-1) was obtained by applying 50% RDIF + FYM @ 31.3 Mt ha-1, which was statistically better to 50% RDIF + FYM @ 11.05 Mt ha-1 (Lamichhane et al., 2022).

ii. Green Manure/Brown Manure:

The process of incorporating a manure crop through tillage prior to seed set, usually around flowering, is known as green manuring (N, et al., 2023). In situ green manuring, commonly utilized in Terai and plain areas with tropical environments, involves using Dhaicha (*Sesbania cannabina, S. rostrata*) in lowlands and Sunhemp (*Crotalaria juncea*) in highland situations. In contrast, farmers in the hilly area collected young leaves and twigs from forests, wasteland, and roadside locations as ex situ green manuring for rice, maize, and potatoes. These plants included Banmara (*Eupatorium adenophorum*), Asuro (*Adhatoda vasica*), Titepati (*Artemesia vulgaris*), Khirro (*Sapium insigne*), Siris (*Albezia lebek*), etc(Vista, et al., 2022)

Generally speaking, brown manuring in rice involves co-cultivating rice and Sesbania spp. After about 25 days, when the height of the dhaincha plants reaches that of the rice plants, a weedicide called 2, 4-D is used to kill the Sesbania plants. Sesbania plants become brown and begin to wither after four to five days of spraying; the leaves drop to the ground, forming mulch that suppresses weeds. Being a selective herbicide, it only destroys Sesbania plants—not rice plants. The is called down knocking effect (N, et al., 2023).Sesbania surface mulch breaks down quickly to release N and other recycled nutrients into the soil (Singh, 2018).As a leguminous crop, it provides 15-20 kg N/ha and 10–12 t/ha of new biomass, which promotes rice crop development and productivity (Das, et al., 2021).

A greater benefit-cost ratio (2.76) was seen when using 125% CDF plus 5 t of Sasbenia green manure per hectare (Baishya et al., 2015-a).With dry matter accumulation at 90 DAS, seed rate @ 40 Kg ha-1, along with brown manuring at 30 DAS, registered highest dry matter accumulation (7061 kg ha-1) and found significantly superior to rest of interactions except knocking down at 25 days at same seed rate. The interaction effect of seed rates and timing of knockdown of dhaincha was significant (Prashanthi Scholar et al., 2022).

Higher grain (6110 and 6324 kg/ha) and straw yields (6973 and 7358 kg/ha) were obtained in 2013–14 and 2014–15, respectively, from planting rice at 25 x 25 cm with dhaincha intercropping and incorporating it by conoweeder at 30 DAS (JOSEPH & HEMALATHA, 2017).

iii. Poultry Manure

Due to high concentration of nitrogen, phosphorus, potassium, and other vital nutrients, poultry manure makes a great organic fertilizer. It enhances soil systems, retention of nutrients, air circulation, soil moisture retention capacity, and water absorption by adding organic matter to the soil as opposed to chemical fertilizers(Cheema &Mohkum Hammad, 2009).The incorporation of PM enhances soil N by over 53%, and it significantly boosts cation exchange capacity(Rasool et al., 2023).The crop that received 2.5 t of poultry manure ha-1 + 125% CDF (75 + 16.5 + 31.3 kg N P and K ha-1) among the nutrient management practices had taller plants (112.27 cm), higher effective tillers (14.60), longer pupales (24.93 cm), grain yield (6.03 t ha-1) and straw yield (9.41 t ha-1) in close succession. The crop that received 2.5 t of poultry manure ha-1 + 100% CDF (60 +13.1 + 25 kg N, P and K ha-1) and 5t FYM ha-1 along with 125% CDF (75 + 16.5 + 31.3 kg N P and K ha-1) also showed taller plants (Baishya et al., 2015b).

iv. Vermicompost:

A combination of undigested organic debris and earthworm castings, also known as vermicompost, is called vermicasts. The finest bedding material is banana trunk, which has been shown to be more palatable for vermi worms than other substrates. Other bedding materials include partially decomposed rice straw, carabao dung, and Aqua regia or Azolla (Javier, Organic based Nutrient Management for Rice Production, 2022).Vermicompost is a naturally occurring fertilizer that is free of harmful chemicals and made from biodegradable organic waste. It may provide nearly all of the main, secondary, and micronutrients needed for plant growth(Malviya et al., 2012).

The rice straw yield in the Vermicompost (VC) treated plots was noticeably higher than in the control plots. When VC was applied, rice grain production rose as compared to the control. The grain yield of a four-split application (T5) was 32% and 142% higher than that of a control and an all-basal treatment, respectively (Bejbaruah et al., 2013).The means of tiller and fresh weight are greater in treatment 3 (50% vermicompost + 50% NPK), while treatment 2 (30% vermicompost + 70% NPK) does not differ significantly from treatment 2. The majority of metrics exhibit the lowest mean value for Treatment T5, which receives 100% of the vermicompost (Lazcano et al., 2008).

v. ***Biofertilizer***

The fixation of atmospheric N by biofertilizers, both in conjunction with plant roots and independently, improves soil fertility by solubilizing insoluble soil phosphates and generating plantgrowthcomponents.Numerous researchers have indicated that the addition of biofertilizers plays a substantial role in boosting soil fertility, yield-attributing characteristics, and final yield(Kawalekar, 2013).

Types of Nitrogen fixing biofertilizers:(Kumawat et al., 2017)

Free living biofertilizers: Nostoc, Anabaena, Azotobacter(0.026-20kgN/ha), Clostridium, Beijerinkia, Klebsiella

Symbiotic: Rhizobium, Frankia, Anabaena azollae

Associative Symbiotic: Azospirillum (10-20 kg N/ha)

The treatments with N, P (50%) and K with biofertilizer (10 t ha-1) showed the significantly highest tiller numbers plant-1 (29), size of panicle (28 cm), weight of 1000 grain (21.31 g), grain (7.26 t ha-1), and straw (13.98 t ha-1) yields, followed by N, P (75%) and K with biofertilizer (5 t ha-1)(Naher, 2018).

vi. Jeevamrutha

Jeevamruth is a miraculous microbial culture that ferments and provides nourishment (Sutar et al., 2018).In addition to giving nutrients, jeevamrutha functions as a catalyst, encouraging the activity of earthworms and other microorganisms in the soil. Additionally, it aids in the prevention of bacterial and fungal infections(Badwal et al., 2019). Jeevamurthawasprepared by combining 1 kilogram of cow dung, 1 litre of cow urine, 200 g of jaggery, 200 g of flour, and 100 g of soil from the same field. The mixture was then well mixed in a large tank, which was kept in the shade and covered with a jute sack to allow for airflow. The mixes were incubated for five days in the shade while being vigorously agitated three times a day for ten to fifteen minutes with a wooden stick. The combinations were finally produced up to 20 liters in plastic containers with water(Kaur, 2020).Cow dung is used fresh not more than 3 days old and prepared solution can be used upto 12 days(Mahanta & Dhar, 2021).When Jeevamrutha was used instead of chemical farming, the benefit-cost ratio increased by 13% to 3.39 from 3.0 for Masura rice output by chemical farming. The Jeevamrutha approach yielded an 81% increase in rice production compared to chemical farming, with a benefit-cost ratio of 1.09 compared to 0.6 for Hamsa rice production by chemical farming (Amareswari & Sujathamma, 2014).Jeevamrutha was given with irrigation every fortnight in the main field.

If the preparation is used nine to twelve days after preparation, the best benefits will be obtained(Devakumar & Gouder, 2014). Jeevamrutha was used in treatments for T4, T5, T7, T8, T9, and T10 on 15, 30, 45, 60, and 75 days after transplanting (DAT). When (T10) NPK 50% + Vermicompost + Panchagavya 3% + Jeevamrutha 5% was applied, the grain yield was noticeably higher at 8713 kg/ha (Sharada & Sujathamma, 2018).

Table 3:Advantages and disadvantages of Organic and Inorganic Nitrogen sources(Hawa et al., 2021)

Type of Nitrogen sources	Advantages	Disadvantages
Organic	• Environmentally friendly and least expensive • Minimizes acidification of soil • Improved tolerance with soil microbes	• Difference in nitrogen % based on different sources • Low Nitrogen % • Decomposition rate is slow
Inorganic	• Dissolves quickly, particularly in wet soil. • Improves plant growth rate and productivity. • Improves crop yields.	• Costly • Overuse may result in soil acidification and nutritional imbalance. • This may lead to ecological problems like pollution of water and eutrophication. • Minimizes soil microbial population.

CONCLUSION

Nitrogen is one of the major nutrient required for increasing production and productivity of rice. This review paper shows that there are various organic and inorganic Nitrogen sources available for growth and yield of rice.Appropriate doses, application time and ratesof nitrogen sources should be considered for favourableyield. Although commercialization has lead to excessive use of inorganic sources, integrated use of these organic and inorganic sources are found to be more beneficial for increasing production and productivity of rice.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

ALL THE ACTIVITIES HAS BEEN DONE BY AUTHER (MYSELF).

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