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Nitrogen dynamics in long term experiment on rice-rice system in an acid inceptisols

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Abstract
Nutrient dynamics refers to the processes involved in the uptake, retention, transfer, and cycling of nutrients within an ecosystem, particularly in soil-plant systems. Soil nutrient content is closely associated with various soil properties, making it a key indicator of nutrient dynamics in these systems. The dynamics of soil nutrients are significantly influenced by the use of fertilisers and manures. Conducting long-term experiments is highly valuable for comprehending changes in the properties of soil and its process, as well as for assessing the sustainability of soil systems. These experiments provide essential insights for developing strategies to maintain soil health and promote environmental sustainability. Enhancing a plant's ability to efficiently utilize nutrients is a crucial aspect of improving environmental sustainability. However, excessive fertilizer application on a crop may not fully react during the current crop season and can leave a residual effect on the succeeding crop. To develop appropriate fertilizer recommendations for crops, it is vital to repeat experiments over time at the same site, considering factors such as climate, soil, fertilizer, and agronomic practices. Long-term fertilizer experiments are, therefore, indispensable tools for advancing technical knowledge and establishing empirical rules for practical agriculture. Applying farmyard manure (FYM) significantly expands the organic carbon and nitrogen pools in the soil. The evolution of CO2 and the mineralizable organic pools of soil nutrients during crop growth are also significantly increased by the use of chemical fertilizers, whether used alone or in conjunction with FYM. The soil organic carbon (SOC) pool in Indian soils, according to research by Lal and Follett published in 2002, is estimated to account for 2.6% of the global pool at a depth of 2 meters and 2.2% at a depth of 1 meter. Despite the fact that the majority of the soil's nitrogen is contained in the form of organic matter, the pool of acid-hydrolyzable amino acids, amino sugars, and amino acids seems to function as a net source of nitrogen for microorganisms and plants. A significant portion of organic nitrogen compounds in the soil is considered to have reserves of nitrogen (N) from the perspective of plant nutrient availability. Understanding the dynamics of phosphorus (P) from soil to plants is crucial for optimizing P management, enhancing P use efficiency, reducing reliance on chemical P fertilizers, promoting soil P acquisition by plants, and facilitating P recycling from manure and waste. The behavior of potassium in the soil is more influenced by cation exchange reactions rather than microbiological processes. Worldwide, sulphur deficiencies in crops have been on the rise due to decreased inputs of sulphur to the soil system and increased sulphur output. Despite their low requirement in plants, the availability of micronutrients is critical for vital plant functions. If micronutrients are unavailable, it can lead to plant abnormalities, reduced growth, and lower yields.

Keywords: Nitrogen dynamic, mineral nitrogen, mineralizable

Introduction
Nitrogen (N) is a crucial element essential for optimal plant growth, particularly for most agricultural crops, which require relatively high amounts of N to achieve maximum yields. However, cereal-cereal cropping systems tend to be more exhaustive, leading to a negative nitrogen balance in the soil. This extensive depletion of nutrients from the soil results in declining system productivity and soil fertility. To meet the food production demands of the present and future population, external inputs of fertilizer N are essential, as its deficiency severely restricts crop yields in cultivated soil. Unlike other essential plant nutrients, nitrogen is not released by the weathering of minerals in the soil. In soil, nitrogen plays a significant role in influencing soil fertility. It exists in both inorganic and organic forms. The majority of nitrogen (95-98%) in most soils is found in organic compounds, while the remaining portion is present in inorganic forms that are readily available to plants. In tropical regions, available nitrogen is often insufficient for plant growth unless efficiently replenished from unavailable forms to available forms such as NH_4^+ and NO_3^-.

Material and Methods

The All-India Co-ordinated Research Project (AICRP) of ICAR has been performing the long term fertilizer experiment (LTFE) at Odisha University of Agriculture and Technology (OUAT), Bhubaneswar, India, since 2005–2006. The experimental site is located at 20°17’ N to 85°49’ E and 30 meters above sea level. A sub-humid sub-tropical climate prevails in the area, with the dry season lasting from October to June and the wet season lasting from July to September. The soil at the test site is categorized as udic ustrocherept and is characterized as sandy loam with an acidic pH of 5.8. The Lalat (IR 2071) rice cultivar was grown as part of the trial in flooded conditions each year during the *rabi* season. In the study, six different treatments were evaluated, including 100% NPK at a rate of 80:40:40 kg/ha of N: P_2O_5:K_2O in urea, MOP, and DAP forms; 150% NPK; 100% NPK + FYM at 5 tons/ha; 10% N at 80 kg/ha of urea-based nitrogen; 100% NP at 80 kg/ha of urea-based nitrogen; 40 kg/ha of urea-based P_2O_5; with a control that wasn't fertilized. Three split treatments with nitrogen were made: 25% as a basal dose, 50% at 18 days after transplanting, and 25% at the start of the panicle. Potassium (K) was applied with 30% as a basal application and 50% at the panicle initiation stage, whereas total phosphorus (P) was applied as a basal application. Using four replicates, the experiment used a randomized block design (RBD). Soil samples were taken from each plot at depths of 0–15 cm, 15–30 cm, and 30-45 cm following the rice harvest in the 2017–18 season (the 24th cycle). The soil samples were processed and dried by air. To determine the electrical conductivity (EC) and pH of the soil, the techniques described by Jackson (1973) were employed. Olsen *et al*. (1954) reported that the phosphorus (P) was extracted using the Olsen reagent (0.5 M NaHCO3 at pH 8.5). Jackson (1973) claimed that available potassium (K) was determined using a flame photometer and extracted using neutral normal ammonium acetate (pH 7.0). Soil organic carbon (SOC) was quantified through the oxidation of dichromate (Walkley and Black 1934) [9]. Page *et al*. (1989) [14] report that the Kjeldahl method was used to calculate the total nitrogen (N) in the soil. Alkaline permanganate was used to determine available nitrogen (Subbiah and Asija, 1956) [8], whereas steam distillation was used by Bermner to measure total hydrolyzable nitrogen (THN), amino acid nitrogen (AAN), acid-insoluble nitrogen (AIN), ammoniacal nitrogen, and nitrate nitrogen. Different nitrogen fractions were determined using standardized methods. Using conventional statistical techniques, the study also involved the creation of basic correlation equations to link different nitrogen fractions with particular chemical characteristics of the experimental soils.

Results and Discussion

Table 1: Effect of long term fertilisation of pH, SOC content and Nutrient status in soil.

Treatments	pH (1:2)	SOC ($g\ kg^{-1}$)	Available nutrients ($kg\ ha^{-1}$)			
			N	P	K	S
100% NPK	4.98	5.4	214	10.6	102	25.4
150% NPK	4.98	5.3	237	11.0	96	32.2
100% NPK +FYM	5.48	7.2	289	58.1	152	37.8
100% N	5.00	3.7	194	8.4	91	18.6
100% NP	5.10	4.0	212	10.7	99	25.6
Control	5.10	3.6	181	6.2	90	18.6
LSD (P=0.05)	0.23	0.73	18.62	3.93	9.23	6.95
Initial	5.80	4.30	187.0	19.14	43.40	22.2

At the beginning of the trial, the soil's initial pH reading was 5.80. The 100% NPK+FYM treatment exhibited a pH fall to 5.48 after 12 years of continuous cropping, indicating a lowering of pH compared to its starting state. At first, the soil's organic carbon content (SOC), which was measured at 4.3 g kg-1, was quite low. But after 12 years of applying balanced mineral fertilizer, either by itself or in conjunction with organic manure, the SOC content was still high by the time the 24th crop in the sequence was harvested. To be more precise, using FYM in addition to 100% NPK increased the carbon content by 33% as compared to using 100% NPK alone.

Inorganic N fractions

Regular applications of chemical fertilizers, either alone or combined with FYM, significantly influenced the soil's levels of both NH4+-N and NO_3-N. The plots treated with less than 100% NPK + FYM had the highest quantities of these nitrogen components, whereas the untreated plots had the lowest values. The inorganic portion of nitrogen, also known as ammoniacal and nitrate nitrogen, made up 3.13 to 8.25 percent of the total nitrogen in the soil. The mineral-N content ranged from 24.00 to 84.67 mg kg-1 in the top 0–15 cm of the soil. It varied between 17.00 and 70.33 mg kg-1 and 10.67 to 51.33 mg kg-1 in the 15–30 cm and 30-45 cm soil depths, respectively. The percentage of mineral nitrogen in the soil was dramatically raised by the regular application of mineral fertilizer along with organic manure. Plots treated with a combined application of mineral fertiliser and organic manure, specifically 100% NPK + FYM, exhibited the maximum concentration of mineral nitrogen. Additionally, the mineral nitrogen concentration in all three soil layers significantly increased with an additional 50% more NPK. The amount of mineral nitrogen absorbed by the soil varies noticeably with depth and steadily declines as depth rises.

Total N

Both the organic and inorganic nitrogen fractions as well as the total nitrogen in the soil were significantly impacted by the long-term application of chemical fertilizers, whether they were employed alone or in conjunction with amendments. The highest nitrogen concentrations were produced by using chemical and FYM fertilisers together, and these values were much higher than those in the other treatments. Contrarily, the amount of total nitrogen (N) in the soil's surface and subsurface layers decreased when rice was grown continuously without fertilization. These results are consistent with those of Bhandari *et al*., who likewise noted a decrease in total soil nitrogen with ongoing rice-wheat cultivation in unfertilized plots.

Soil Organic Fraction

The amount of organic nitrogen (N) components in the soil increased significantly as a result of the application of mineral fertiliser, with THN (Total Hydrolysable Nitrogen), rising from 471.21 mg kg-1 soil in the unfertilized control to 621.80 mg kg-1 soil. In all three soil layers, the 100% NPK + FYM treatment showed the greatest THN values. Comparing the unfertilized control to plots with a single addition of N, a P inclusion with N, or a combination application of N, P and K, the amount of THN in the unfertilized control dramatically decreased. Only a 6% rise in THN compared to the 100% NPK treatment was seen in the surface level, while a significant improvement (36%) In comparison to the unfertilized control, THN was observed in the 100% NPK + FYM treatment. In plots treated with mineral fertiliser, the following changes in THN content were graded according to their magnitude: In all three soil depths, 100% NPK + FYM was more effective than 150% NPK, 100% NP, 100% N, and 100% N > control. All the organic N fractions, including hydrolyzable NH4+-N, amino acid-N, hexosamine-N, and unidentified hydrolysable-N, significantly increased in the integrated treatment (100% NPK + 5 t ha-1 FYM), whereas their concentrations were at their lowest in the control and plots that only received inorganic fertilizers. The ASN (Amino Sugar Nitrogen) fraction had the lowest N concentration among the several hydrolyzable N fractions, whereas the UHN (Unidentified Hydrolysable Nitrogen) fraction had the greatest. Regardless of the treatment, the UHN portion predominated the total hydrolyzable N.

In addition to increasing the quantity of organic nitrogen, the administration of NPK and FYM encouraged the immobilization of N in various hydrolyzable fractions. This might be explained by increased biomass production and the dominance of cereal crops, which provide a lot of roots and stubbles to the soil. Combining organic manure and inorganic fertilizer has been shown to promote the growth of organic forms of nitrogen (N). Beyond the advantages of NPK alone, FYM increased all forms of organic N in the soil. Thanks to the balanced FYM and NPK used in rice-rice cropping systems, a notable rise in the organic content was made after 39 years. The amounts of amino acid N and amino sugar exhibited similar trends, with pig dung + NPK treatment resulting in the greatest values and NPK fertilizer treatment resulting in the lowest values.

Table 2: Effect of long-term manuring and fertilization on the vertical distribution of organic nitrogen fractions, total nitrogen, and accessible nitrogen in the soil.

0-15cm								
Treatment	**Total N**	**Mineral N**	**THN**	**HAN**	**Amino acid –N**	**Amino sugar-N**	**UNH**	**NHN**
100% NPK	729.0	57.00	621.80	134.13	125.63	32.33	329.70	50.20
150% NPK	752.3	69.00	667.00	145.06	157.07	28.06	327.27	16.33
100%NPK+FYM	1045.3	84.67	762.20	189.63	174.00	37.97	360.73	198.47
100% N	639.3	43.33	545.87	122.80	119.73	19.67	283.67	50.13
100% NP	715.6	45.67	556.80	133.07	134.40	20.27	269.07	113.20
CONTROL	607.6	24.00	471.27	115.53	93.60	14.20	247.93	112.40
LSD(P=0.05)								
15-30cm								
100% NPK	632.3	47.33	445.20	81.33	93.60	18.20	252.07	139.80
150% NPK	686.0	52.67	444.53	80.80	95.87	21.20	237.07	188.80
100%NPK+FYM	836.3	69.00	560.00	137.27	141.33	29.67	251.73	207.33
100% N	572.0	28.00	376.53	72.53	74.40	16.60	213.00	167.47
100% NP	630.3	42.33	414.40	82.40	92.27	19.93	219.80	173.60
CONTROL	671.8	17.00	334.33	50.07	61.87	9.20	213.20	185.67
LSD(P=0.05)								
30-45cm								
100% NPK	558.6	35.00	306.13	35.47	53.60	11.47	205.60	217.53
150% NPK	583.0	45.00	446.20	42.37	68.27	13.90	321.67	91.80
100%NPK+FYM	717.0	51.33	406.67	52.20	85.07	18.07	251.33	259.00
100% N	533.3	21.00	309.13	32.47	51.20	9.93	215.53	203.20
100% NP	573.3	32.33	323.33	42.80	58.80	17.70	204.03	217.67
CONTROL	482.3	10.67	298.67	24.63	38.73	8.83	226.47	173.00
LSD(P=0.05)								

Yield and total uptake

Rice produced 43.47 q ha-1 of grain and absorbed 83.78 kg ha-1 of total nutrients as a result of the treatment of both FYM and 100% NPK. Following closely behind was the 150% NPK treatment, which had a grain yield of 34.69 q ha-1 and a total nutrient intake of 61.89 kg ha-1. When compared to 100% NPK alone, the 100% NPK + FYM treatment increased nutrient uptake by 69%, and when compared to 100% NPK alone, the 150% NPK treatment increased nutritional uptake by 24%. While also enhancing the physical and biological conditions of the soil, the addition of FYM was essential in delivering all nutrients, including micronutrients. In investigations by Sawarkar *et al*. (2013) [15] and Singh *et al*. (2014) [12], the positive effects of FYM with NPK were similar. According to Narwal and Choudhury (2006) [11], the application of both organic manure and chemical fertilizer accelerates microbial activity, enhances the availability of native nutrients to plants, and increases the rate at which nutrients are absorbed by plants. There was no discernible difference between the treatments in the harvest index, which varied from 0.40 to 0.47. The relative agronomic efficiency, calculated as Kg grain / Kg nutrient, showed variations between 5.31 and 20.50. The treatments of 100% NPK + FYM and 100% NPK, which recorded the highest yield, also exhibited the highest agronomic efficiency. The control treatment had the lowest harvest index due to the lowest grain yield.

Table 3: Effect of different treatment on yield, total uptake, Aparent N Recovery, Agronomic efficiency, and Harvesting Index

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Total Uptake (kg ha^{-1})	ANR (kg kg^{-1})	AE (kg kg^{-1})	HI
100% NPK	30.63	35.69	49.30	42.2	11.79	0.46
150% NPK	34.69	38.19	61.89	38.6	9.70	0.48
100%NPK+FYM	43.47	48.19	83.78	85.3	20.50	0.47
100% N	17.51	22.06	24.10	10.7	5.32	0.44
100% NP	21.86	27.75	33.17	22.0	8.84	0.44
Control	13.25	19.91	15.58	0.0	0.00	0.40
LSD (p=0.05)	4.54	5.56	9.00		-	-

Correlation study

The grain yield and N uptake of rice showed significant correlations with all organic N fractions, as indicated in Table 4. These results suggest that hydrolyzable N fractions play a crucial role as a source of mineral N, which in turn enhances N uptake and the overall yield of the rice crop. Among all the hydrolyzable N fractions, amino acid-N and amino sugar-N showed strong correlations with both yield and N uptake, surpassing the correlations observed for ammonia-N and hydrolyzable unknown N fractions. AAN, ASN, and inorganic N were found to positively correlate with grain yield and rice N uptake. Reddy *et al*. (2003) [1] also noted that amino acid N had the highest connection with mineralizable N, supporting their findings.

Table 4: Relationship between different soil nitrogen fractions, grain yields, and rice's uptake of nitrogen (r)

	Grain N	N uptake
TOTAL N	0.93**	0.95**
Mineral N	0.95**	0.96**
THN	0.98**	0.99**
HAN	0.94**	0.96**
AAN	0.94**	0.95**
ASN	0.95**	0.95**

**significant at 1% level of significance

Conclusion

Under the rice-rice cropping system, regular fertilizer use and the addition of organic manures enhanced the mineral and organic soil N components. Continuous cultivation without fertilization results in depletion in the different nitrogen fractions in the soil depth up to 45cm. To increase N accumulation and availability of N, it is necessary to supply N fertilizer as per the crops needs in addition to organic manure as well as with other nutrients. The total N content of the soil is increased by applying farm yard manure (FYM) and mineral fertilizer (NPK) continuously to the soil. Combining chemical fertilisers with organic manure may be a superior alternative for storing nitrogen in soil and for improving the soil's physical characteristics to increase crop output.

Reference

1. Reddy KM, Singh M, Tripathi AK, Singh M, Saha MN. Changes in amount of organic and inorganic fractions of nitrogen in an *Eutrochrept* soil after long-term cropping with different fertilizer and organic manure inputs, Journal of Soil Science and Plant Nutrition. 2003;166:232-238.
2. Bremner J. Organic forms of nitrogen. *In*: Methods of soil analysis. Part II-Chemical and microbiological, Black CA (ed.). ASA, Madison, WI. 1965;1238-1255.
3. Bhandari AL, Ladha JK, Pathak H, Padre AT, Dawe D, Gupta RK. Yield and soil nutrient changes in a long-term rice-wheat rotation in India, Soil Science Society of America Journal. 2002;66:162-170.
4. Bhattacharyya P, Nayak AK, Mohanty S, Tripathi R, Shahid M, Kumar A, *et al*. Greenhouse gas emission in relation to labile soil C, N pools and functional microbial diversity as influenced by 39 years long-term fertilizer manage-ment in tropical rice, Soil and Tillage Research. 2013;129:93-105.
5. He HB, Li XB, Zhang W and Zhang XD. Differentiating the dynamics of native and newly immobilized amino sugars in soil frequently amended with inorganic nitrogen and glucose, European Journal of Soil Science. 2011;62:144-151.
6. Jackson ML. Soil chemical Analysis. Prentice Hall of India, Pvt. Ltd., New Delhi; c1973.
7. Sekhon KK, Singh JP, Mehla DS. Long-term effect of manure and mineral fertilizer application on the distribution of organic nitrogen fractions in soil under a rice–wheat cropping system, Archives of Agronomy and Soil Science. 2011;57(7):705-714.
8. Subbiah BV, Asija GL. A rapid procedure for assessment of available nitrogen in soils, Current Science, 1956;31: 159-160.
9. Walkley AJ, Black JA. Estimation of soil organic carbon by the chromic acid titration method, Soil Science. 1934;37:29-38.
10. Xie W, Zhou J, Wang H, Chen X, Lu Z, Yu J, Chen X. Short-Term Effects of Copper, Cadmium and Cypermethrin On Dehydrogenase Activity and Microbial Functional Diversity In Soils After Long-Term Mineral or Organic Fertilization, Agriculture, Ecosystems and Environment. 2009;129:450-456.
11. Narwal RP, Chaudhary M. Effect of Long-Term Application of FYM and Fertilizer N on Available P, K and S Content of Soil, In 18th World Congress of Soil Science , Philadelphia, Pennsylvania, USA; c2006.
12. Kaur J, Singh J. Long-term effects of continuous cropping and different nutrient management practices on the distribution of organic nitrogen in soil under rice-wheat system, Plant, Soil and Environment. 2014;60:63-68.
13. Olsen SR, Cole CV, Watanabe FS and Dean LA. Estimation of available phosphorus in soils by extraction with sodium biocarbonate, US Department of Agriculture Circular. 1954;939:21-29.
14. Page AL, Miller RH, Keeny DR. (Eds), Methods of Soil Analysis, Part-2, Chemical and Micro-biological Properties, 2nd Edn. No (9) Part-2 in the series, Agronomy, American Society of Agronomy, Madison, Wisconsin, USA; c1982.
15. Sawarkar SD, Khamparia NK, Thakur R, Dewda MS and Singh M. Effect of Long-Term Application of Inorganic Fertilizers and Organic Manure on Yield, Potassium Uptake and Profile Distribution of Potassium Fractions in Vertisol under Soybean-Wheat Cropping System, Journal of the Indian Society of Soil Science, 2013;61(2):94-98.