Effect of FYM and Fertilizer Application on Soil Organic Nitrogen Fractions: A Review

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Abstract: Nitrogen is the key element among the major nutrients required in crop production and most of the Indian soils are deficient in this nutrient. To supplement nitrogen, along with other inorganic sources, extensive and continuous application of mineral fertilizers may cause imbalance in the soil micro flora in the long term and directly or indirectly influence the biological properties of soil. The Indo-Gangetic plains are located within the tropical and subtropical regions of India and are among the most agriculturally productive areas in the country. The average soil organic carbon content of the soils in the region is, however, low due to intensive cultivation along with prevailing high temperatures and humidity. Nitrogen is the major limiting plant nutrient in this region, with N availability being routinely supplemented through application of fertilizers. Soil organic N fractions were found to be affected markedly with nitrogen fertilization directly through changing the composition of soil N & indirectly through affecting crop growth.

Keywords: FYM, Fertilizer, Nitrogen Fraction, Crop Growth

I.INTRODUCTION

Nitrogen (N) occupies a unique position among the elements essential for all plants because of its large amounts required by most agricultural crops. Soil Organic Nitrogen (SON) plays a key role in terms of plant nutrition through direct and indirect effects on microbial activity and nutrient availability. As a consequence of mineralisation-immobilisation turnover, N exists in soil in different organic (Stevenson, 1982) and inorganic forms. Plants are usually thought to take up NH_4^+ and $N0_3^-$ ions, with the latter being favoured when it is available in abundance. Also, plants are able to take up urea directly in the absence of hydrolysis. Supply of high N favors the conversion of carbohydrates into proteins, which in turn promotes the formation of protoplasm .Since it is a necessary component of all proteins, N is involved in all plant growth processes. Ammonical nitrogen and amine sugar nitrogen and the balance were referred to as unidentified nitrogen. hydrolysable ammonical nitrogen is one of the major part of soil organic nitrogen drive from the decomposition of amide amine sugar, amino acid fixed ammonical nitrogen on the fine mineral and some nitrogen-containing mineral (Stevenson, 1982). Wander et al. (2007) observed that the easily hydrolysable fractions, especially amino acid N, amino sugar N, amine N and hydrolysable NH_4-N can provide an assessment of soil organic N changes induced by management such as cropping system and inorganic and organic fertilizations. Huang et al. (2009) observed no change in organic N fractions with inorganic fertilization but increased significantly with the application of organic manures with or without inorganic fertilizers. Understanding the effect of organic amendments on the transformation of organic N into different forms is a prerequisite for managing N inputs in a given soil. The present study was undertaken to quantify temporal changes in soil organic N fractions over time under continuous cropping with differential nutrient management practices. Organic N fractions viz. total hydrolysable-N, amino acid-N, amino sugar-N, hydrolysable unknown-N and nonhydrolysable-N were determined by the method given by Stevenson (1996).

II.EFFECTS ON NITROGEN FRACTIONS

1) Depletion of nitrogen fractions:

Cultivation of rice-wheat continuously for 13 years without any fertilization (control) decreased all the four hydrolysable-N fractions (Amino Acid-N (AAN), Amino SugarN (ASN), Ammonia-N (AMMN), hydrolysable unknown-N (HUN) significantly over their initial status (Table 1). However, the magnitude of decrease varied markedly depending upon the hydrolysable N form and amounted to 37.2, 29.6, 33.7 and 10.4% depletion in AAN, ASN, AMMN and HUN, respectively over their initial status in surface soil (Figure 1). The greater depletion of hydrolysable N forms under continuous cropping without manuring compared to adjacent fallow was also reported by Rao and Ghosh (1981). The extent of depletion in Total Hydrolysable (THN) N fraction was more (26.6%) than that in Non Hydrolysable N (NHN) fraction (20.4%) over their initial status due to continuous cropping (Figure 1). The relatively greater decrease in THN supports the observation that hydrolysable N is more vulnerable to mineralization and could be considered as a major source of potentially available N for plants than non-hydrolysable N (González-

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Prieto et al. 1997). Thirteen years of rice-wheat cropping without any fertilizers or organic amendments (T1) significantly lowered the initial status of soil N from 432 to 324 mg/kg resulting in 25.1% depletion in surface soil (Table 1 and Figure 1). Bhandari et al. (2002) also found a decline in total soil N with continuous rice-wheat cropping in unfertilized plots.

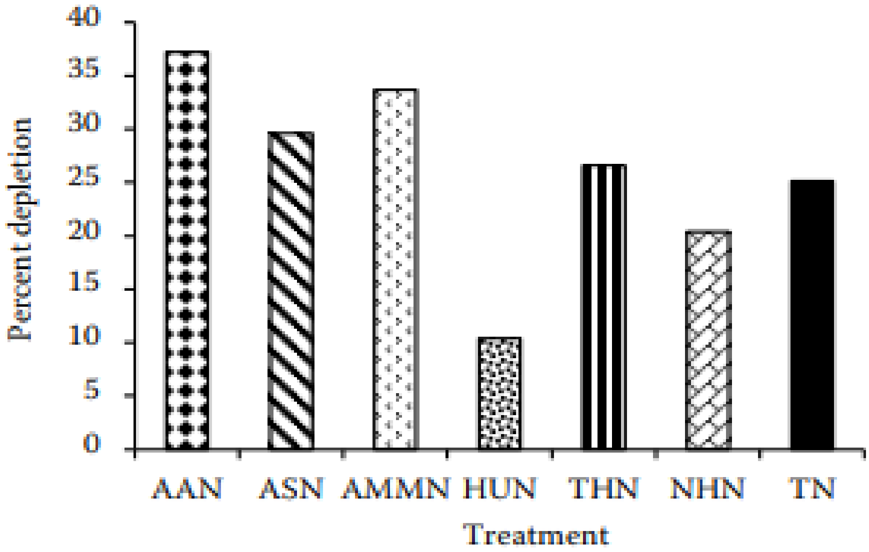

Figure 1. Effect of continuous cropping for 13 years without any N fertilization on the changes in N fractions and total N over their initial status.(AAN – amino acid N; ASN – amino sugar N; AMMN – ammonia N; HUN – hydrolysable unknown N; THN – total hydrolysable N; NHN – non-hydrolysable N; TN – total N)

2) Nitrogen build-up

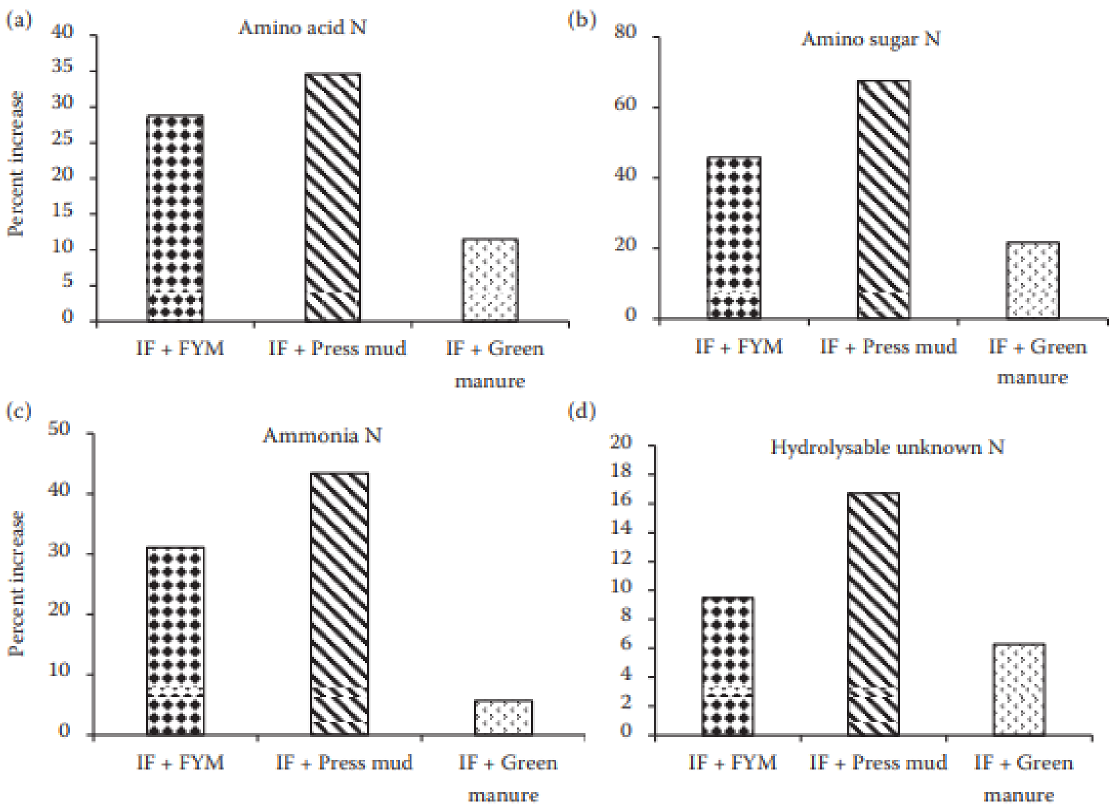

Figure 2. Effect of different organic amendments on the changes in amino acid N (a), amino sugar N (b), ammonia N (c) and hydrolysable unknown N (d) over inorganic fertilizer (NPKZn) treatment after 13 cycles of rice-wheat cropping. IF – inorganic fertilizers

Contrary to the decrease in unfertilized treatment, all four hydrolysable N fractions and non hydrolysable N registered a significant increase due to inorganic fertilizers or organic amended treatments over their respective initial status (Table 1). The magnitude of increase in all the hydrolysable N fractions over their initial level was more with combined application of inorganic fertilizers and organic manures as compared to inorganic fertilizers alone. Huang et al. (2009) concluded that organic manure had a more significant effect on soil N than inorganic fertilizer alone. The extent of N build-up in hydrolysable N factions varied with the N fractions and organic manure. There was a build-up of 28.8, 34.6 and 11.6% in AAN under FYM, press mud and green manure amended treatment, respectively over inorganic fertilizer treatment (N150P32.8K62Zn5) (Figure 2a). Farmyard manure, press mud and green manure incorporation along with inorganic fertilizers increased the ASN by 45.9, 67.6 and 21.6%, respectively over inorganic fertilizer treatment (Figure 2b). Application of inorganic fertilizers in combination with organic manures (FYM, press mud and green manure) resulted in build-up of AMMN over N150P32.8K62Zn5 (T2). However, the effect of FYM and press mud was more pronounced as compared to green manure treatment (Figure 2c). The HUN increased by 9.5, 16.7 and 6.3% over treatment with inorganic fertilizer alone (T2) due to FYM (T3), press mud, (T4) and green manure treatments (T5), respectively (Figure 2d).

Table 1. Effect of different treatments on N content of organic nitrogen fractions

	Different N forms(mg/kg soil)						Total N(mg/kg)
NO	AAN	ASN	AMMN	HUN	THN	NHN	
T1	59	19	61	95	234	90	324
T2	104	37	106	126	373	124	497
T3	134	54	139	138	465	147	612
T4	140	62	152	147	501	167	668
T5	116	45	112	134	407	130	532
T6	105	36	105	129	375	125	500
Initial	94	27	92	106	319	113	432
LSD $_{0.05}$	16	10	28	12	52	18	58

AAN – amino acid N; ASN – amino sugar N; AMMN – ammonia N; HUN – hydrolysable unknown N; THN – total hydrolysable N; NHN – non-hydrolysable N

A major part of the soil N was in organic conjunction, which one acid hydrolysable (62- 87 percent of total soil nitrogen) and organic N hydrolysable forms were the amine acids, hydrolysable Ammonical N and amine sugar and the balance were used to as unrecognized nitrogen (Stevenson 1982). Most N enters soil as protein content or some part of biological polymers, which required to be extracellular before they are use for uptake by soil microorganism or plant (Jan et al., 2009); Weintraub and Schimel 2005). The behavior of amino acids and peptides in soil has received a lot of attention in recent years due to their proposed role in plant nutrition (jamtguard et al., 2010; Hill et al., 2011).

It has been studied that amine sugar (5 and 12% of total soil organic nitrogen) is a significant reservoir of both carbon and nitrogen in soil (Knicker 2011). Repeated use of chemical fertilizers, alone or in conjunction with organic manure for 7 years, led to reported increase in total nitrogen, hydrolyzable nitrogen (amino acid nitrogen, amino sugar nitrogen, Ammonia nitrogen, hydrolyzable unknown nitrogen) and non hydrolyzable nitrogen compared with their basic status of soil (Sekhon et al., 2011).

Haung et al. (2009) observed that no change in inorganic N fractions within organic fertilization but influenced significantly with the use of organic manures with or without inorganic fertilizers. Ikemura and Shukla(2009) reported that continuous addition of organic manure significantly increased the soil nitrate-N and ammonical-N in certified organic farms. Bharti (2013) found that continuous use of chemical fertilizers and amendments for 36years in an acid Alfisol brought out marked increase in the organic and inorganic fractions of N, total N and available compared to the untreated plots, further found that among all the fractions, hydrolysable NH_4 -N was found to play a major role in the supply of nitrogen while NH_4 -N was the most important fraction bearing the highest correlation with crop yield and total nitrogen. Application of organic manure @15 tha^{-1} significantly increases total nitrogen from 0.203 per cent to 0.349 per cent (Tadesse et al., 2013).

In rice-rice cropping system, application of farmyard manure (FYM) with NPK as balanced fertilization resulted in higher organic N accumulation over a period of 39 years (Bhattacharyya et al., 2013). Liang et al. (2014) found that application of organic manure increased total nitrogen increased with their increase of soil organic carbon by reducing soil bulk density over the mineral fertilizer treatments. Roy and Kashem (2014) reported that continuous application of organic manure increase soil NH_4-N and NO_3-N in soil with increased soil organic matter significantly. Bharath Patil (2015) reported that organic farming increased the total N and available N in soil. The contents of inorganic N fractions of soil viz., NH_4^+-N and NO_3^--N as well as organic fractions viz., hydrolysable-N, hexamine-N, amino acid-N and total hydrolysable–N recorded higher in organically managed soils besides amino acid N was dominant fraction contributing to total N.

Stevenson and Cole (1999) reported that the nitrogen found in soil can generally be classified into inorganic and organic forms. The larger amount (95 to 99%) occurs in the organic forms as a part of the soil organic matter complex and micro flora which is not immediately available to growing plants, which was acid hydrolysable (62 to 87 per cent of the total soil nitrogen) and the main organic –N hydrolysable forms were the amine acids (30-45% of total N), amino sugars (5-10% of soil total N) and hydrolysable (10-20% of TN) and the balance were referred to as unidentified N. Haung et al (2009) studied that use of N influcened by organic fertilization was primarily concentrated into amino acid-N, hydrolysable unknown N and non-hydrolysable nitrogen. Guldekar and Ingle (2009) reported improved status of N fractions with the application of N in combination with FYM, Zn and S. The relative abundance of N fractions in soil followed the order insoluble humin-N > hydrolysable NH_4^+-N + amino sugar-N > amino acid-N > acid soluble humin-N > fixed NH_4^+-N >NO_3-N > exchangeable NH_4^+-N.

Zhang et al. (2009) Long term use of optimum dose of NPK either alone or in conjunction with FYM resulted in a significant increase in the amount of hydrolysable N fraction in soil. A significant increase in the total hydrolysable N, mainly through hydrolysable unknown N was observed during the cropping sequence. Tabassum et al. (2010) reported that repeated applications of fertilizer N alone, N with FYM or poultry manure or urban compost, FYM alone led to a significant increase in organic C, total N, hydrolysable N (i.e.amino acid N, hydrolyzable NH_4-N, hexose amine N) and non-hydrolysable N in both surface and subsurface soils as compared to initial status in a vertisol soybean-wheat cropping system.

Sekhon et al. (2011) reported that continuous application of mineral fertilizers alone or in combination with organic manures for 7 years, led to marked increase in total nitrogen, hydrolysable N (amino acid-N, amino sugar-N, ammonia-N, hydrolysable unknown-N) and non-hydrolysable N compared with their original status in soil.

Kaur and singh (2014) reported that Cultivation of rice-wheat continuously for 13 years without any fertilization (control) decreased all the four hydrolysable-N fractions (amino acid-N (AAN), amino sugar N (ASN), ammonia-N (AMMN), hydrolysable unknown-N (HUN) significantly over their initial status, Contrary to the decrease in unfertilized treatment, all four hydrolysable N fractions and non hydrolysable N registered a significant increase due to inorganic fertilizers or organic amended treatments over their respective initial status. Durani et al (2017) observed that Continuous application of inorganic fertilizers, alone or in combination with organic manure led to marked increase in the total soil N, total hydrolysable- N(THN) (amine acid-N, ammonical-N, amine sugar-N, hydrolysable unknown N) and non-hydrolysable-N. The effect of FYM with 100% NPK in maize-wheat was more pronounced in increasing the total soil N and THN.

III.SUMMARY AND CONCLUSION

The results from Experiments revealed that the application of NPK+FYM showed higher content of N-fractions viz. Total hydrolysable-N, Hydrolysable ammonical-N, inorganic–N, hexose amine & hydro.ammo.-N, hexose amine-N, amino acid-N, unidentifi ed hydrolysable-N, non-hydrolysable-N and total N. Available soil organic nitrogen improved with balance dose of NPK further enhanced with FYM over control.

REFERENCES

[1]. Bhandari, A. L., Ladha, J. K., Pathak, H., Padre, A. T., Dawe, D., & Gupta, R. K. (2002). Yield and soil nutrient changes in a long-term rice-wheat rotation in India. Soil Science Society of America Journal, 66(1), 162-170.
[2]. Durani, A., Safiullah, K., andDurani, H. (2017).Effect of long-term application of organic and inorganic fertilizers on maize-wheat cropping system at different forms of nitrogen and soil properties.IJAR, 3(9), 525-532.
[3]. González-Prieto, S. J., Jocteur-Monrozier, L., Hétier, J. M., & Carballas, T. (1997). Changes in the soil organic N fractions of a tropical Alfisol fertilized with 15 N-urea and cropped to maize or pasture. Plant and soil, 195(1), 151-160.
[4]. Haung, Z.Q., Xu, Z.H., Chen, C. R. and Boyd, S. (2009). Change in the soil carbon during establishment of a hardwood plantation in subtropical Australia. Forest Ecol. Mgt., 254,46-55.
[5]. Hill, P.W., Quilliam , R.S., DeLuca, T.H., Farrell, Roberts, P., Newsham, K.K., Hopkins, D.w., Bardgett, R.D. and Jones, D.L. (2011). Acquistiton and assimilation of nitrogen as peptide-bound and D-enantiomers of amino acids by wheat. Plos One., 6,19-20.
[6]. Ikemura, Y, andShukla, M.K.(2009).Soil quality in organic & conventional farms of New Mexico, USA.Jour of Organic Systems, 4(1), 34-47

[7]. Jämtgård, S., Näsholm, T., and Huss-Danell, K. (2010). Nitrogen compounds in soil solutions of agricultural land. Soil Biology and Biochemistry, 42(12), 2325-2330.
[8]. Jan, M. T., Roberts, P., Tonheim, S. K., and Jones, D. L. (2009). Protein breakdown represents a major bottleneck in nitrogen cycling in grassland soils. Soil Biology and Biochemistry, 41(11), 2272-2282.
[9]. Kaur, J.,and Singh, J. P. (2014). 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, 60(2), 63-68.
[10]. Knicker, H. (2011). Soil organic N-An under-rated player for C sequestration in soils?. Soil Biology and Biochemistry, 43(6), 1118-1129.
[11]. Rao, A. S., & Ghosh, A. B. (1981). Effect of continuous cropping and fertilizer use on the organic nitrogen fractions in a Typic Ustochrept soil. Plant and Soil, 62(3), 377-383.
[12]. Roy, S., andKashem, M. A. (2014). Effects of organic manures in changes of some soil properties at different incubation periods. Open Journal of Soil Science, 4(03), 81.
[13]. Sekhon , K.S., Singh, J.P. and Mehla , D.S. (2011). Long- term effect of manure and mineral fertilizer application on the distribution of organic nitrogen fractions in soi;l under a rice-wheat cropping system. Arch. Agron. Soil Sci., pp, 1-10.
[14]. Stevenson FJ, Cole MA (1982). Cycles of soil (carbon, nitrogen, phosphorus, sulphur and micronutrients).2 nd Ed. New York. 1999, 191-229
[15]. Tabassum S, Sammi KR, Vaishya UK, Muneshwar S, Biswas AK. Changes in Organic and Inorganic Forms of Nitrogen in a TypicHaplustert under Soybean-Wheat System due to Conjoint Use of Inorganic Fertilizers and Organic Manures. J. Indian Soc. Soil Sci. 2010; 58:76- 85.
[16]. Tadesse T, Dechassa N, Bayu W, Gebeyehu S. 2013. Effects of farmyard manure and inorganic fertilizer application on soil physico-chemical properties and nutrient balance in rain-fed lowland rice ecosystem.Am J Plant Sci. 4:309–316.
[17]. Weintraub, M. N., and Schimel, J. P. (2005).Seasonal protein dynamics in Alaskan arctic tundra soils. Soil Biology and Biochemistry, 37(8), 1469-1475.
[18]. Zhang J, Qin J, Yao W, Bi L, Lai T, Yu X (2009). Effect of long-term application of manure and mineral fertilizers on nitrogen mineralization and microbial biomass in paddy soil during rice growth stages.Pl. Soil Environ; 55:101-109.