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Impact of amendments on soil organic nitrogen fractions irrigated with sodic water

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ABSTRACT

Present study was carried out to evaluate the effects of FYM and gypsum on organic nitrogen fractions in soil of long-term field experiment irrigated with sodic water since 1994 at research farm of Department of Vegetable Science, CCS Haryana Agricultural University Hisar, India (2014-2015). Field was irrigated with high RSC (11.5 me/l) sodic water having three levels of gypsum G_0 (control), G_1 (50 % neutralization of RSC), G_2 (100% neutralization of RSC), along with three levels of FYM; F_0 (control), F_1 (10 tonnes/ha), F_2 (20 tonnes/ha). The Results obtained in April 2014 showed that all N fractions (Non hydrolysable-N, NH_3-N, amino acid-N, amino sugar-N, hydrolysable unknown-N and total hydrolysable-N) were more dynamic in various treatments consisting FYM and gypsum levels. All nitrogen fractions increased with increasing levels of FYM and gypsum. Averages of amino acid nitrogen, amino sugar nitrogen, ammonia nitrogen and hydrolysable unknown nitrogen constituted about 28-30, 9-12, 27-29 and 29-36% of total hydrolysable nitrogen, respectively. Adverse effect of residual alkalinity of irrigation water was quite prominent on chemical properties (pH, EC, organic carbon) of soil. The pH of soil was found to be very high under F0G0 and decreased with the use of FYM and gypsum as amendments. This result indicates that the combined use of FYM and gypsum improved soil health and maintained the sustainability of the different vegetable cropping system.

Key words: Amino acid nitrogen, Amino sugar nitrogen, Ammonia nitrogen, Hydrolysable nitrogen

Long term and indiscriminate use of sodic water cause accumulation of salt which not only adversely affects the physical and chemical properties due to swelling and dispersion of clay particles in addition to increased pH, EC and exchangeable sodium percentage (ESP) (Minhas *et al.* 2007), But also modifies the quality of soil organic matter as well as soil organic nitrogen. To offset the harmful sodic water effect, application of gypsum is a common recommendation; organic amendments such as FYM have been used as these can modify Ca from $CaCO_3$ and other Ca bearing minerals in soils (Chaudhary *et al.* 2007). Soil organic matter is the key contributors to soil productivity directly through controlling the availability of soil available nitrogen (N) and indirectly through regulating the soil physical, chemical and biological properties. The soil organic nitrogen fractions are widely used as measures for evaluating the soil fertility. Main difference among these fractions is related to degree of decomposition, recalcitrant, and turnover rate. 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 (Wander *et al.* 2007, Kaushik *et al.* 2018)

A better understanding of N transformation processes that occur in key labile organic N fractions is necessary to recognize their role in N cycling and their relative contribution to N mineralization. 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. So, identifying the fraction of soil organic nitrogen into different pools and quantitatively analyzing these pools are better means of understanding C and N dynamics. The present study was undertaken to quantify changes in soil organic N fractions under continuous application of FYM and gypsum under sodic water irrigation conditions.

MATERIALS AND METHODS

Site characteristics

The present study was conducted using the experiment units (plots) of an ongoing permanent long-term experiment started in 1994 and it is located at Vegetable Research Farm, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar (2014-15) situated at 29°10' North latitude and 75°46' longitude at the mean elevation of 215.2 m. Temperature fluctuated between 1.9°C (January) and 47°C (May) during the year. Normal annual rainfall of

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the district is 330 mm and about 75 to 80 % of total rainfall is received during the month of June to September. The soil of the experimental field was sandy loam, *Typic Ustochrept* having 19.6 % clay and 9.3 C mol/kg CEC in depth of 0-30 cm layer. The experimental treatments were laid out in randomized block design having three levels of FYM (0, 10 and 20 t/ha represented as F_0, F_1 and F_2 respectively) and three doses of gypsum (0, 50 and 100% neutralization of RSC represented as G_0, G_1 and G_2, respectively). These treatments were replicated thrice irrigated with sodic water from farm tube well having the average ionic composition dominated by HCO^-_3 (13.3 me/l) of Na^+ (15.8 me/l) and having the average values of EC, RSC and SAR of 2.4 dS/m, 11.5 me/l and 14 mmol/1 $^{1/2}$ respectively during past 20 years. The fertilizers were applied @ 125 kg N, 50 kg P_2O_5 and 100 kg K_2O/ha in all the plots of sizes of 3.0 m × 3.0 m. The average nutrient composition of FYM used in the experiment were organic carbon 38 %, N 1.20%, P 0.97% and K 1.87 % and gypsum had 23.1% calcium and 18.6 % sulphur.

Analysis of soil samples

Soil samples were collected from 0-15 cm depth from all the plots in the month of April 2014. Samples were air-dried, ground and passed through 2 mm sieve. Chemical properties were analysed by the methods as outlined by Jackson (1973).The different organic nitrogen fraction, *viz* acid insoluble-N, hydrolysable NH_3-N, amino acid-N, amino sugar-N, hydrolysable unknown-N and total hydrolysable-N were determined by the method given by Stevenson (1996).

Statistical analysis

The data obtained under study were statistically analyzed using randomized block design. Comparisons among treatment means were made using the least significant difference (LSD) calculated at $P < 0.05$ subjected to statistical analysis for significance using OPSTAT software.

RESULTS AND DISCUSSION

Soil pH, electrical conductivity and organic carbon

Application of FYM and gypsum decreased the soil pH over the condition where no amendments were applied. The highest pH (9.4) was observed under F_0G_0 condition while lowest value (7.60) was observed under F_2G_2 condition. Application of FYM and gypsum increased the removal of Na from soil exchange complex and hence decrease the soil pH. Similar results were also reported by several workers (Choudhary *et al.* 2011, Kumar *et al.* 2012 and Bahadur *et al.* 2013). As comparison to pH, EC of the soil increased with increasing levels of FYM and gypsum. The EC of soil increased from 0.48 dS/m in F_0G_0 to 1.41 dS/m in F_2G_2 treatment. Electrical conductivity of saturation extract decreased with irrigation of sodic water may be due to precipitation of Ca + Mg (Pareek and Yadav 2011). Results of present study were similar to the findings of Choudhary *et al.* (2011) and Kumar *et al.* (2012).

Addition of FYM and gypsum significantly increased SOC content in soil from 4.2 % in F_0G_0 to 7.2 % in F_2G_2 treated plots , because under improved soil physical environment, carbon inputs was higher in the forms of more root biomass and above ground small plant residue. Addition of gypsum also increased the aggregation stabilization from the formation of Ca-organic linkage in the form of clay particle -Ca-organic molecule (Baldock *et al.* 2000).

Organic nitrogen fractions

Lowest total nitrogen (N) was observed where FYM and gypsum was not applied (F_0G_0), attributed due to no nutrient application which directly or indirectly affected normal biological activities (Table 1). However, highest total N was found in plots where 20 t FYM/ha and gypsum @ 100% neutralization of RSC was applied and this is mainly due to better biological activities. Results showed that there is 17% increase of total N in F_2G_2 over control and 16% increase in F_2 as compared to F_0 treatments, respectively. Total N increased with increasing levels of FYM because of the addition of organic-N content in FYM (Huang *et al.* 2009). Similarly, total-N also increased with gypsum application due to addition of more crop residue under improved soil physical conditions, but the effect of gypsum for total-N was less as compared to FYM. The interaction between FYM and gypsum levels was not significant for total N content in soil.

The mean value of total hydrolysable nitrogen (THN) increased significantly with increasing levels of FYM and gypsum (Table 1), this could be ascribed to the increase of soil biological activities and repeated addition of N in organic form. A non-significant interaction was observed between FYM and gypsum on THN content of soil. It is generally assumed that where microbial growth is C-limited, microbes will use C from dissolve organic matter to support

Table 1 Effect of FYM and gypsum on total nitrogen (kg/ha) and total hydrolysable nitrogen (kg/ha) under sodic water irrigation

Total nitrogen				
Treatment	G0	G1	G2	Mean
F0	725	728	730	728
F1	805	806	810	807
F2	845	846	850	847
Mean	792	793	797	
CD at (P=0.05) FYM=6.04 Gypsum=NS F×G=NS				

Total hydrolysable nitrogen				
Treatment	G0	G1	G2	Mean
F0	508	508	511	509
F1	588	590	595	591
F2	620	623	629	624
Mean	572	574	578	
CD at (P=0.05) FYM=4.52 Gypsum=4.52 F×G=NS				

their energy needs and release hydrolysable-N (Schimel and Bennett 2004 and Bardgett 2005). THN was about 70 to 74 % of total N present in soil and usually about 26-30% is recovered as non-hydrolysable-N which is acid insoluble. There was 24 % and 23% increased in THN in F_2G_2 and F_2 over F_0G_0 and F_0 respectively. Kaur and Singh (2014) also observed 24.7 % increased in THN with the application of FYM plus inorganic fertilizer, over that obtained in treatment with inorganic fertilizers alone. Khandagle *et al* (2019) also observed the increased in THN under integrated application of FYM and inorganic fertilizers.

Non hydrolysable nitrogen (NHN) increased significantly with increasing levels of FYM but increasing trend of more values supports the view that total hydrolysable N is more susceptible to mineralization than non-hydrolysable N (Sammi *et al.* 2003), However, with application of gypsum, there is decrease in non-hydrolysable nitrogen. Results showed that there was 33% and 27% increase of ammonia nitrogen (AN) in F_2G_2 and F_2 over F_0G_0 and F_0, respectively. Similarly there was 3% increased of AN in G_2 as compared to G_0 treatments (Table 2). This type of results was due to release of an appreciable amount of soil N as ammonium during acid hydrolysis (Stevenson 1996). When FYM and gypsum was not applied, the ammonia-N decreased due to increase in pH of soil which resulted N loss from the soil in the form of NH_3 volatilisation.

Application of FYM significantly increased the total hydrolysable unknown nitrogen (THUN) value over no FYM application, while gypsum application significantly decreased the THUN over no gypsum application (Table 2). The interaction between FYM and gypsum levels showed significant difference on THUN content. The total hydrolysable unknown N was higher than other fraction of hydrolysable N. FYM is bulky in nature and less rapid decomposition rate so that it contributes more in total hydrolysable unknown N in soil (Sihag *et al* .2005).

Amino sugar nitrogen (ASN) was also increased significantly with the increasing levels of FYM and gypsum (Table 3). Application of FYM leads to higher accumulation of SOC and it favours more microbial biomass under improved soil physical environment. The ASN is believed to be largely of microbial origin and thus its value found to be increased. Similar type of results observed by Benner and Kaiser (2003), indicates that microbial growth is favoured by higher content of SOC, which leads to an increase in the occurrence of glucosomine, muramic acid and other amino sugars. In the present study, there was 65% and 49% increased of ASN in F_2G_2 and F_2 over F_0G_0 and F_0, respectively. Similarly, about 7% increased of ASN was observed in G_2 as compared to G_0 treatment. Kaur and Singh (2014) also reported 45.9 % increased in ASN under combined application of FYM and inorganic fertilizers as compared to inorganic fertilizer alone.

The amino acid nitrogen (AAN) increased significantly with the application of FYM and gypsum application over control (Table 3). Long term application of FYM can store more organic matter in the soil and after decomposition of native organic matter will lead to increased availability of free and peptide band amino acids (Trumbore 2000). Application of gypsum also increased the SOC content in soil and improves the soil physical environment which favours the microbial biomass and also amino acid-N in soil. There was 33 % and 28 % increased of AAN in F_2G_2 and F_2over F_0G_0 and F_0, respectively.

All four hydrolysable N fractions and non-hydrolysable N registered a significant increased due to inorganic

Table 2 Effect of FYM and gypsum on hydrolysable unknown nitrogen (kg/ha) and ammonia nitrogen (kg/ha) under sodic water irrigation

Total hydrolysable unknown nitrogen				
Treatment	G0	G1	G2	Mean
F0	183	170	169	174
F1	188	189	184	187
F2	190	188	182	187
Mean	187	182	178	
CD (P=0.05) FYM=1.60 Gypsum=1.60 F×G=2.78				

Ammonia nitrogen				
Treat ments	G0	G1	G2	Mean
F0	137	143	143	141
F1	165	165	168	166
F2	177	177	182	179
Mean	160	162	165	
CD (P=0.05) FYM=1.38 Gypsum=1.38 F×G=2.40				

Table 3 Effect of FYM and gypsum on amino sugar nitrogen (kg/ha) and amino acid nitrogen (kg/ha) under sodic water irrigation.

Amino sugar nitrogen				
Treatment	G0	G1	G2	Mean
F0	45.7	49.7	51.1	48.8
F1	64.7	65.5	67.8	66.0
F2	70.7	72.5	75.5	72.9
Mean	60.4	62.6	64.8	
CD (P=0.05) FYM=0.68 Gypsum=0.68 F×G=1.19				

Amino acid nitrogen				
Treatment	G0	G1	G2	Mean
F0	142	146	148	145
F1	171	171	174	172
F2	182	185	189	186
Mean	165	167	170	
CD (P=0.05) FYM=1.25 Gypsum=1.25 F×G=NS				

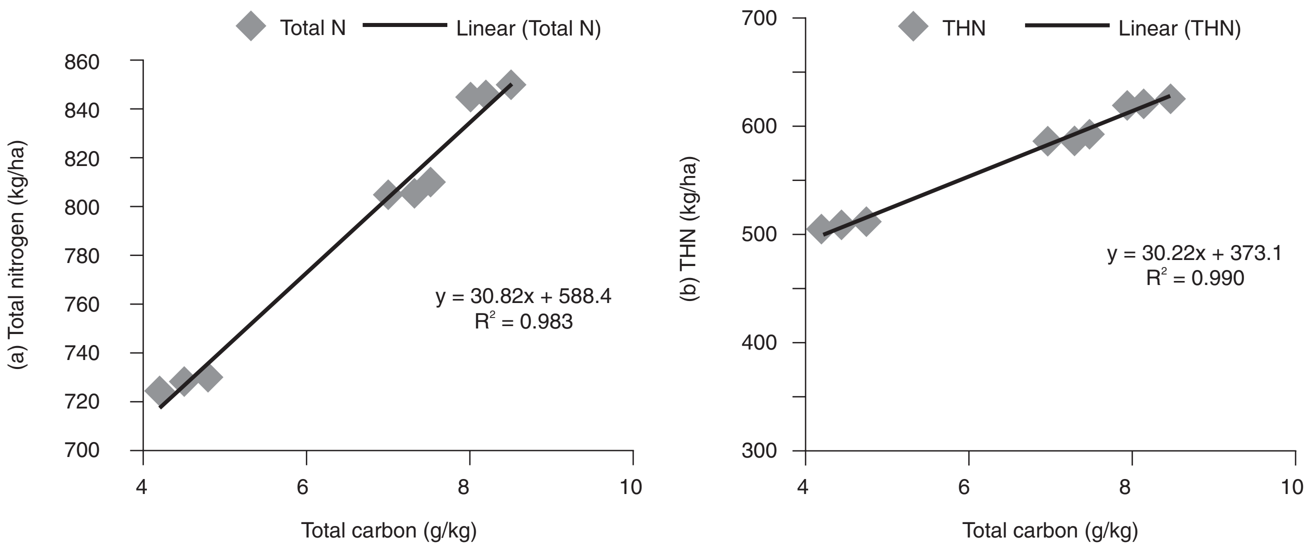

Fig 1 Relationship between soil organic carbon and total nitrogen (a) and total hydrolysable nitrogen (b).

fertilizers or organic-amended treatments over their control level as also reported by Shekhon *et al.* (2011) and Kaur and Singh (2014) at another location in the region. Amongst various hydrolysable-N fractions, the lowest content of N was recorded in amino sugar-N and highest in hydrolysable unknown-N. The hydrolysable unknown-N was the most dominant fraction of total hydrolysable-N, regardless of treatments applied.

Conclusion

Continuous irrigation of soil with sodic water without any amendment increased the soil pH while EC was found decreased. The application of FYM and gypsum also increased the SOC content. Similarly application of FYM and gypsum increased the availability of soil organic nitrogen fractions in soil. On average amino acid nitrogen, amino sugar nitrogen, ammonia nitrogen and hydrolysable unknown nitrogen constituted about 28-30, 9-12, 27-29 and 30-34 % of total hydrolysable nitrogen, respectively. A highly significant correlation was observed between soil organic carbon and total nitrogen ($R^2 = 0.983$) and total hydrolysable N (R^2=0.990), respectively. These results indicated that the use of FYM in conjunction with gypsum is very important for ensure better soil health and sustaining crop productivity on long term basis. It can be further conclude that application of 20 t FYM/ha along with gypsum 100 % neutralization of RSC of irrigation water should be applied for maintaining soil quality and productivity.

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