NITRIFICATION DYNAMICS IN SOIL DUE TO VARIATION IN CO₂ LEVEL

Haroon Shahzad, Muhammad Iqbal, Atif Javed, Sarvet Jehan, Researchers
Institute of Soil & Environmental Sciences, University of Agriculture, Faisalabad, Pakistan
E-mail: haroonshahzad_stu@uaf.edu.pk

ABSTRACT

Nitrification process in the soil is oxidation reaction that occurs in aerobic environment. Under anaerobic environment reduced conditions prevails inhibiting nitrification process. A lab incubation study was designed to assess the effect of CO₂ level on nitrification in soil. Soil samples were taken in container and incubated for two weeks under conditions, (i) 0, 1 and 2% ground farm manure mixed with soil and (ii) with and without KOH solution to trap CO₂. Each of the treatment was replicated 12 times. Three soil samples were discarded after analysis for NH₄ and NO₃-N after 0, 5, 10 and 15 days of incubation showing significant decrease in nitrification rate with decreased CO₂ level. Organic matter added in the form of farm manure enhanced nitrification rate especially in KOH treated container.

KEY WORDS

Incubation; CO₂ absorber; KOH; Nitrification.

Organic matter addition in soil has multifarious useful impacts on nutrient availability, water uptake efficiency and crop growth. Soil physical (Edmeades, 2003), chemical and biological health is considerably dependent upon quality and quantity of organic matter (Deksis et al., 2008). Organic matter content of soil has direct relationship with soil fertility and nutrient availability to plant especially nitrogen that under goes several microbial modification as mineralization, immobilization (Shimpi and Savant, 1995), nitrification and denitrification (Burferd and Bremner, 1975). Immobilization of N is due to complex formation of organic molecules that is rapid when simple sugars are present in soil (Ahmad et al., 1973). Denitrification is resulted from easy oxidation of carbonaceous material by soil microbes (Burford and Bremner, 1975) developing microsite anaerobiosis (Arah, 1997). Denitrification is a substrate limited process depending upon NO₃ availability (Williams et al. 1998). NO₃ prepared is not the only loss by denitrification but the intermediates of nitrification also lost as oxides. (Azam et al., 2002). That is the reason nitrification process is most important process in N-cycle for ecosystem similar as well as environmental hazards (Abbasi and Adams, 2000). NH₄ is role source for nitrification that is utilized by nitrosomonas and nitrobactor using CO₂ as carbon source (Aleem, 1965). Organic amendment as agricultural management practice that enhances nitrification and consequently denitrification. Reduced nitrification is reported as CO₂ partial pressure is reduced (Azam et al., 2005). Study was envisaged to assess the impact of CO₂ level variation in soil environment on nitrification pace in soil.

MATERIALS AND METHODS

Soil samples were collected from research area Institute of Soil & Environmental Sciences, University of Agriculture, Faisalabad. Samples were air dried ground and sieved using <2 mm mesh sized sieve.

500 g soil was taken in steel cup with NH₄ content added @ 200 mg kg⁻¹ of soil and treated on weight bases with 1 - 0% Farm Manure (FM₀); 2 - 1% Farm Manure (FM₁); 3 - 2% Farm Manure (FM₂).

Keeping two CO₂ levels one treated with KOH solution to trap CO₂ while other having free CO₂ present. Each treatment was triplicated 4 times in steel cups closed with perforated lids for exchange of gases and incubated at 25 °C. Triplicated cups were removed at 0, 5, 10 and 15 days of incubation from each treatments for NH₄-N and NO₃-N analysis. 20g soil mixed with 50 mL 1N KCl solution shaking on reciprocating shaker and then filtered using

what man No. 42. Filtrate was analyzed for $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ using kjeldhal method (Keeney and nelson, 1982).

RESULTS AND DISCUSSION

Fig.1(a, b and c) present data of $\text{NH}_4\text{-N}$, $\text{NO}_3\text{-N}$ and total nitrogen content of soil incubated for 15 days with and without farm manure application. Nitrification is a rapid process but these margins have been selected for complete process. As regarding $\text{NH}_4\text{-N}$ content which decrease rapidly as days passed by. Even substantial decrease was observed after 5 days of incubation which is assimilated in preference to nitrification (Jansson, 1958).

Table 1 - Pre-incubated soil characteristics

Soil Parameter	Unit	Amount
pH		8.2
EC	dSm^{-1}	2.3
Organic C	%	0.45
Total N	%	0.06
$\text{NH}_4\text{-N}$	mg kg^{-1}	5
$\text{NO}_3\text{-N}$	mg kg^{-1}	11
Sand	%	
Silt	%	
Clay	%	
Texture	Loam

Figure 1(a) - $\text{NH}_4\text{-N}$ (mg kg^{-1}) of soil

As soil was dried and remoistened so most of carbon was released that can be resulted in immobilization of $\text{NH}_4\text{-N}$. Significant decrease in $\text{NH}_4\text{-N}$ content was observed with farm manure and extent of reduction was more in 2% than 1% farm manure and negligible quantity of $\text{NH}_4\text{-N}$ was observed in 2% FM. This reduction is partly attributed to immobilization and nitrification. (Azam et al., 1985; Lodhi et al., 2006) reported substantial immobilization of N during wheat straw decomposition. Fig. 1(c) is not following this reason as $\text{NH}_4 + \text{NO}_3\text{-N}$ content is observed insignificantly unstable during whole incubation period. So nitrification is considered main reason for decrease of $\text{NH}_4\text{-N}$ content. Fig. 1(b) shows a rapid nitrification process with increasing $\text{NO}_3\text{-N}$ content due to loss of $\text{NH}_4\text{-N}$ that is being nitrified during incubation. Soil CO_2 content also significantly contributes to nitrification. CO_2 entrapped in the aggregates reduced nitrification is observed but the addition of farm manure relieved the process. While under normal CO_2 content nitrification is not FM regulated.

Figure 1(b) - NO₃-N (mg kg⁻¹) of soil

Figure 1(c) - Total Soil Nitrogen content (mg kg⁻¹)

Figure 1(d) - Total Soil Nitrogen content (mg kg⁻¹)

So it is indicated that nitrification is controlled by CO_2 that is used by autotrophs responsible for nitrification while FM added serves as organic carbon source for the microbes that release CO_2 upon respiration. These results suggested that increase in soil CO_2 content by organic matter addition regulate nitrification process. Fig. 1(d) shows $\text{NO}_3\text{--NH}_4$ ratio that gives extent of nitrification. At 5 days average ratio for various FM level was 0.2, 0.28 and 1.07 when CO_2 level was low while at normal conditions 0.25, 0.85 and 2.86, respectively, indicating higher nitrification under normal environment. The variation become more prominent after 10 days with ratios of 0.24, 0.44, 1.91 and 0.29, 1.31 and 6.7, respectively, under absorbed and normal conditions. 0.25, 0.6, 4.24 and 0.29, 1.32 and 13 was the observed $\text{NO}_3\text{--NH}_4$ ratio after 15 days when nitrification is almost complete. So it is clearly defined that organic amendment enhances the nitrification process indirectly. Nitrification is enhanced with enhancing available C and CO_2 level (Azam et al., 2005). As CO_2 in soil is higher due to microbial and root respiration (Certini et al., 2002), so nitrifiers work at higher levels of CO_2 (Hungate et al., 1999).

CONCLUSION

Results assume organic matter as most crucial component in nitrification process. As O.M and CO_2 are removed from soil the nitrification will be curtailed. So easily decomposable O.M favors de nitrification not only due to avail C but also due to higher CO_2 content by enhancing nitrifier activity.

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AUTHOR'S CONTRIBUTION

Study was planned and conducted by Mr. Haroon Shahzad. Miss Sarvet Jehan helped in soil analysis. Format was written by Mr. Haroon Shahzad and Mr. Atif Javed. Dr. Muhammad Iqbal supervised the study and reviewed the written content.

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