NITRIFICATION DYNAMICS UNDER SUBMERGED AND AERATED SOIL CONDITIONS

Shahzad H., Iqbal M.

Institute of Soil & Environmental Sciences, University of Agriculture

Faisalabad, Pakistan

E-mail: rhs2140@ymail.com

ABSTRACT

Nitrogen is a pivotal component of proteins making 60% dry matter of plant cell. It is reported deficient in most of the soils of world. An incubation study was conducted to assess N-transformations under aerobic and submerged conditions using organic amendment. Maximum oxidation of NH_4 was observed in organically amended soils followed by control treatment. Nitrification is NH_4 to NO_3 conversion process was observed to be lowest under submerged condition. With passage of incubation time NO_3 content in organically amended and control treatment get enhanced while under flooded conditions least declining trend in NH_4 content was observed from start to ending days. Least N losses were observed in organically amended aerated soil.

KEY WORDS

Aerated, aerobic, nitrification, mineralization, submerged.

Food security is most discussable issue these days because of increasing population. To meet the needs of population agriculture production has to be enhanced utilizing same piece of land. The success story of arable farming without N fertilizer seems impossible because N is deficient in majority of soils. Fertilization aims optimized crop yield and quality that can give high economic returns for the investment. Nitrogen is considered most important nutrient with least uptake efficacy because nitrogenous fertilizers are subjected to various reactions, transformations and nitrogen loss mechanisms i.e. NH_3 volatilization [(Sluan and Audesson, 1995)] nitrification, denitrification [(Rolston and Broadbent, 1977)], leaching [(Wild and Cameron, 1980 ; Nielson 1982)], immobilization [(Shimpi and Savant, 1975)] and runoff [(Takamua *et al.*, 1977)]. So major proportion of applied N is lost by these processes [(Smith and Whitfield, 1990; Shah *et al.*, 1993)]. Efficacy of N is very almost 50% for upland grain crops [(Roy and Chandra, 1979)] but only 30-45% for lowland rice [(Vlek and Craswell, 1981; Zia & Waring, 1987)].

Major objective of today agriculture is to get more economic yield with least cost that can only be achieved through enhancing nutrient use efficiency. Major N application for optimum crop growth all over the world is in the form of urea that upon hydrolysis increases soil pH causing tremendous losses in the form of ammonia volatilization [(Fan *et al.*, 1993; Hamid *et al.*, 1998)]. Redox reactions resulting from alternate flooding and drying cycle also causes N losses by nitrification and denitrification [(Burferd and Bremner, 1975)]. Fertilizer management practices can be one way to reduce N losses [(Rao *et al.*, 1987; Fiez *et al.*, 1995; Saad *et al.*, 1996)]. These practices are fruitful when someone understand the transformation procedure [(Saad *et al.*, 1996)]. Present study was, therefore, envisaged to understand N transformation under aerobic & flooded condition.

Materials and Methods

A controlled field study was conducted to evaluate the N transformations under aerated and submerged condition using organic amendment. Following treatment plan was used:

- T0 = control [(aerobic)]
- T1 = Aerobic + Organic liquid
- T2 = Flooded / Submerged

Cores were inserted in soil so as not to disturb the soil natural environment at field

research area Institute of Soil and Environmental Sciences, University of Agriculture Faisalabad, Pakistan.

Physicochemical characteristics of soil before study are given in Table 1.

Table1 - physicochemical analysis of soil used in study

Parameter	Units	Value
Sand	%	40
Silt	%	37.5
Clay	%	22.5
texture clam		Loam
pH		8.2
Bulk density	Mg m ⁻³	1.52
EC _e	dS m ⁻¹	1.45
Total carbon	%	0.5
Total N	%	0.03
K	mg kg ⁻¹	112
P	mg kg ⁻¹	8

Moisture content was maintained at 75% of WHC in control and organically amended treatments by addition of DI water and organic liquid, respectively. In T₂ soil was flooded by DI water. Each treatment was replicated 18 times. Three cores were sacrificed each time for analysis of NH₄ and NO₃ as samples after 0, 1, 2, 4, 7, 11 and 15 days of starting study.

50 mL 1N KCl solution added to 20 g soil in a plastic bottle and mixed by shaking on reciprocating shaker. Then it was filtered using Whatman No. 42 filter paper. Kjeldahl method was used for NH₄ and NO₃ analysis [(Keeney and Nelson, 1982)].

RESULTS OF RESEARCH

Studies account for nitrogen transformation under various soil conditions have given divergent results and various explanations have been advanced for each effect.

Amonical N in soil [(NH₄-N)]: NH₄ concentration under different treatment dropped significantly with passing days. Maximum reduction was observed in control aerated followed by organically amended and submerged treatments as evident from (fig. 1).

Less amount of NH₄ -N in control is due to its nitrification while elimination of air from pores by water create reduced condition that inhibit nitrification [(Vlek and Craswell, 1981)]. [Saffinga *et al.*, (1982)] have presented the same concluding remarks. In organically amended soil amount of NH₄ was higher that was supposed to be due to sheltering of NH₄ ion to the negative site of organic matter leaving least amount prone to nitrification. After 11 days NH₄ content increased again due to mineralization of organic pool and stimulatory effect of NH₄ ion on nitrification prior to hydrolysis reduced NH₃ volatilization [(Hamid *et al.*, 1998)].

Nitrate Nitrogen [(NO₃-N)] in Soil: Concentration of NO₃ -N enhanced gradually in the whole run described in (Fig. 2). Maximum increment was observed in organically amended treatment followed by control and submerged soil. In start control produced more NO₃ upto 2 days as more NH₄ was prior to nitrification than other two treatments. In starting days NH₄ was bound to negative charge bearing sites of organic material but later on due to mineralization of organic matter NH₄ released and oxidized to form NO₃. Nitrification of NH₄ to NO₃ was lowest under submerged conditions due to lower oxygen in soil. These results matches with [(Wild and Cameson, 1980; Magalhaes and Chalk, 1987; Saad *et al.*, 1996)].

Mineral N and losses: Mineral N (NH₄ + NO₃-N) under control and organically amended treatment increased with incubation time (Fig-3) adopting almost same increasing trend in both treatments. While declining trend was observed for submerged conditions. For both aerated treatments decline was observed for the very first day but a sharp increase after that because of mineralization of organic matter under aerobic condition. Mineral N content was declined continuously from day 0 to end of the term that is attributed to denitrification of nitrate by microbes and oxygen was not present for NH₄ oxidation or organic matter decomposition. These results are fulfilling the concluding lines of [(Saffigna *et al.*, 1982; Magalhaes and Chalk, 1987)].

Figure 1 - Ammonium dynamics in soil under aerobic and anaerobic enviroments

Figure 2 - Nitrate dynamics in soil under aerobic and anaerobic enviroments

Figure 3 - Mineral N dynamics in soil under aerobic and anaerobic enviroments

CONCLUSION

From this study it is concluded that under submerged conditions major loss of nitrogen is due to denitrification process. Such type of losses can be reduced by creating aerobic environment through better soil management practices.

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