韓土肥誌(1998)
Vol. 31(3) : 233~237

시용된 유기물 종류별 토양중 질소무기화

이종식* · Donald A. Graetz**

Nitrogen Mineralization in Soils Added with Different Organic Materials

Jong-Sik Lee* and Donald A. Graetz**

ABSTRACT

Mineralization of organic N is an important factor in determining the appropriate rate for organic waste application to cropland. The mineralization of organic N was examined using sandy soil amended with three kinds of compost (municipal solid waste+biosolid, yard trimmings, yard trimmings+biosolid), respectively. During the 12-week incubation, the mineralization of organic N was determined by analyzing the inorganic N in leachates from unamended and amended soils. Soils amended with composts made of biosolid had higher initial NH_4-N concentration than unamended soil. Soil amended with compost made of yard trimmings only had slightly lower initial inorganic N concentration than unamended soil. In the soil amended with compost made of yard trimmings+biosolid, however, nitrification rate was enhanced in the first week of incubation. Net N mineralization and nitrification were positive in all treatments. Although the greatest net N mineralization occurred in the soil amended with compost made of yard trimmings+biosolid, the greatest net mineralization and nitrification rates occurred in unamended soil.

Key words : mineralizatiion, nitrification, organic waste, municipal solid waste, biosolid, yard-trimmings.

Introduction

One of improved management practice for N involves the use of slowly-available N sources in place of rapid-available N fertilizer salts to decrease leaching potential. Slowly-available N sources include both expensive controlled-release fertilizers and inexpensive organic waste sources such as manure, biosolid, and composts(King, 1984). Application of organic waste to agricultural land can help solve waste management problems by sensibly recycling organic C and N.

Florida soils are generally sandy and low in organic matter contents. They have a low nutrient and water retention capacity and low native fertility. Addition of organic matter tends to enhance their overall ability to retain both nutrients and water. However, excessive waste application rates may result in N contamination of groundwater(Spalding & Exner, 1993). Thus, it is important that the interaction between wastes and soils be known to effectively utilize

* 농업과학기술원(National Institute of Agricultural Science and Technology, RDA, Suwon 441-707, Korea)
** 플로리다대학교(Soil and Water Science Department, Institute of Food and Agricultural Sciences, Univ. of FL, FL 32611-0510, USA)

the plant nutrients and minimize the potential for adversely affecting soil or groundwater (Laanbroek & Gerards, 1991; Wiseman & Zibilske, 1988).

In determining the appropriate application rate of organic waste to cropland, it is critical to know its mineralization rate. This is especially important for N, since much of N in organic waste is in the organic form.

N mineralization rates from organic waste applied to land vary depending on soil and environmental conditions as evidenced by a variety of studies reported in the literature (Bernal & Kirchmann, 1992; Douglas & Magdoff, 1991; Keeney et al., 1975; Parker & Sommers, 1983; Sabey et al., 1975). The availablity of N in the soil is regulated by numerous interacting process, including plant uptake, microbial mineralization and immobilization and diffusion. The complexity of interactions among these process contributes to current difficulties in assessing soil N availability. For measuring of soil N availability, many methods are based on chemical extractions, laboratory or field incubations, bioassays, isotopic dilution and enrichment techniques, or ion exchange resin techniques(Binkley, 1984; Binkley & Matson, 1983; DiStefano & Gholz, 1986; Nadelhoffer, 1990; Schnabel, 1983).

In our study, we used laboratory incubation to compare N mineralization and nitrification potentials of soils of different amendments. The objective of the study was to investigate the effects of the soil amendment on soil N dynamics.

Materials and Methods

The sandy experimental soil having C/N ratio of 59.31 was collected from Hernando County, Blooksville, FL.

Compost A was made of mixture of municipal solid waste and biosolid(2:1). Compost B was made of yard-trimmings only and its C/N ratio was 30.0(Table 1). Yard waste was often quite dry and had a high C/N ratio. Compost C was composted with mixture of yard-trimmings and biosolid with 1:1 ratio for adjusting moisture and C/N ratio. Soil was amended with compost with 200 Mg ha^{-1} ratio.

Table 1. Properties of soils and composts used in the experiment

Materials	C (%)	N (%)	C / N
Soil	1.602	0.027	59.31
Compost A	36.08	1.24	29.19
Compost B	22.23	0.74	30.00
Compost C	27.02	1.60	17.11

A 150ml Nalgene filterware(CN 0.45 ㎛, Nalgene Brand Products) was used to allow non-destructive measurements of leachable N from unamended and amended soil samples incubated under controlled conditions. This filter unit consists of an upper part and a lower chamber separated by a filter. The upper chamber has a detachable lid and a port below the filter.

Remove the lid of filterware and add glasswool prefilter which may facilitate rapid sample leaching, paticularly in amended soils with organic wastes. Add 50 g of soil sample to the upper chamber.

After samples were prepared, they preleached with the distilled water and evacuate to a desired soil moisture tention (10 kPa). Therafter, soils were aerobically incubated in the dark at 25 ℃. Alternating measurement of N mineralization were made at 1- to 4- week intervals during a

12-week incubation period. Soil moisture content was monitored weekly by reweighing of the assembled filterware and was collected by adding distilled water.

At each time during the incubation period that N minerization was measured, a 100 ml distilled water was poured into the upper chamber and allowed to equilibrate with each soil sample for 1 hour. After equilibration, leachates were extracted with a 10kPa vacuum through the port until at least 5 min after the flow of solution into lower chamber had ceased. Leachates were analyzed colorimetrically for NH_4-N(Technicon Autoanalyzer II, Technicon Instruments Corporation) and NO_3-N(RFA, ALPKEM Corporation).

N mineralization rates in incubated samples were calculated as mass of mineral N leached from a sample divided by the number of week since the previous leaching and expressed as mg N per g of soil N per week(mg N g^{-1} of N wk^{-1}).

Results and Discussion

Measurements of N mineralization conducted on replicate samples show that reproducible estimates can be obtained for soils incubated in this device. As with results of the series of measurements conducted during the 12-wk incubation period, soils amended with composts made of biosolid(compost A and C) led to pronounced differences among soil treatments in initial inorganic N concentration. The soils amended with compost A and compost C had significantly higher initial NH_4-N concentrations than unamended soils (Table 2). In these treatments, NH_4-N concentration remained relatively same concentration throughout the incubation.

Table 2. Initial inorganic N concentrtion in unamended and amended experimental soils (mean: n=3)[a]

Soil treatment	NH_4-N	NO_3-N
	mg N kg^{-1} soil	
Soil (Control)	0.452c	1.653ab
Soil + Compost A	25.035b	1.795a
Soil + Compost B	0.471c	1.433c
Soil + Compost C	31.373a	1.749ab

[a] For each variable, different letters at the end of treatment denote significant differences between means calculated by Duncan's multiple range test following ANOVA ($P<0.05$)

In soils without biosoild, NH_4-N concentration remained low throughout the incubation; soil inorganic N was primarily NO_3-N (Fig. 1. a and c). Subler et al.(1995) reported similar results that soils without legume leaves had low NH_4-N concentrations throughout the incubation. Soil amended with compost B (yard-trimmings) had slightly lower total inorganic N concentration than unamended soil.

In the all soils, except treatment A, total inorganic N concentration increased steadily throughout the incubation, indicating continuous net N mineralization. In the soil amended with compost C, nitrification rate was relatively high in the first week and NO_3-N concentration was higher than NH_4-N after two-week incubation. Differences in the rate of initial net mineralization and net nitrification were probably due to differences in the quality of the organic amendments as substrates for microbial growth. The compost C had the lowest C/N ratio of 17.1 among the amendments in this study (Table 1).

At the end of the 12-week incubation, net N mineralization and nitrification were positive in all treatments. Although the greatest net N mineralization occurred in the treatment C(Fig. 1), the greatest net mineralization and nitrification rates occurred in unamended soil

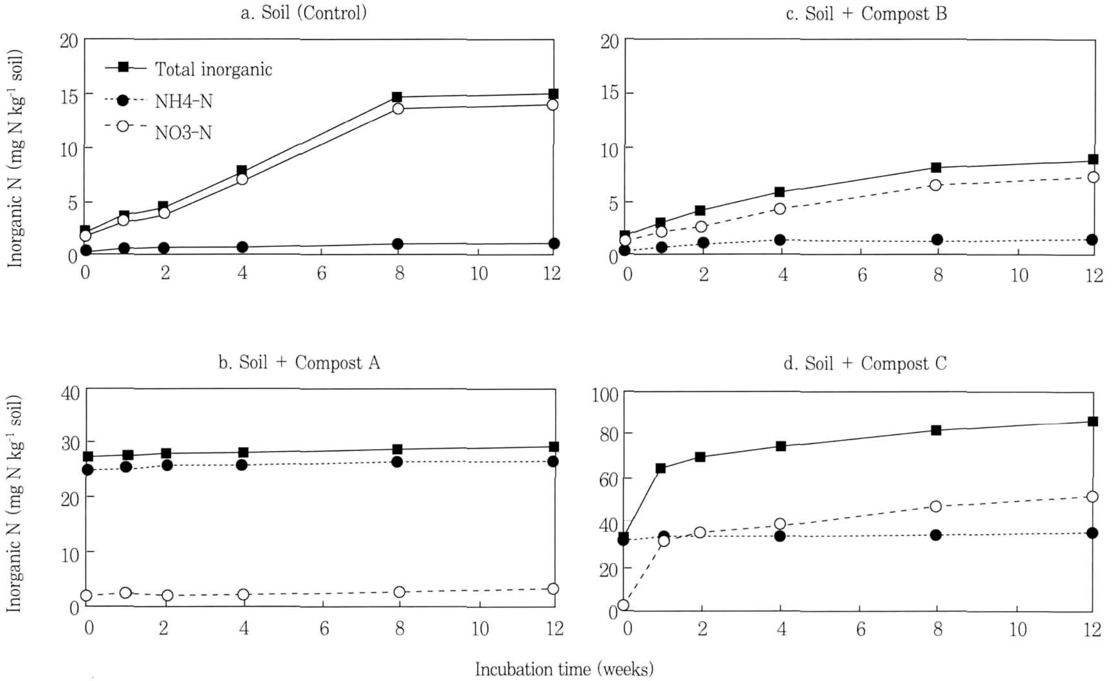

Fig. 1. Cumulative inorganic N concentrations in unamended and amended soils during the 12-weeks incubations. Total inorganic N was calculated as sum of NH_4-N and NO_3-N.

Table 3. Mineralization and nitrification rates during 12-week incubation of soil

Weeks incubated	Mineralization (mg g^{-1} of N wk^{-1})				Nitrification (mg g^{-1} of N wk^{-1})			
	Control	Soil + Compost A	Soil + Compost B	Soil + Compost C	Control	Soil + Compost A	Soil + Compost B	Soil + Compost C
1	5.578	0.332	1.071	17.776	5.156	0.128	0.662	16.672
2	3.267	0.287	1.220	2.073	3.111	0.061	0.860	1.819
4	5.948	0.061	0.929	1.572	5.600	0.049	0.812	1.322
8	9.013	0.073	0.593	1.096	6.213	0.053	0.571	1.053
12	0.235	0.045	0.265	0.699	0.209	0.023	0.257	0.671

(Table 3).

The C/N ratios of compost A and B were higher than compost C, therefore it was expected that greater N immobilization in treatment A and B. This may explain the lower rates of net N mineralization and nitrification in treatments with compost A and B than control.

In our study, a series of extraction of inorganic N from incubated soil sample probably affects the subsequent changes in soil NH_4-N and NO_3-N concentrations resulting from microbial nitrification, denitrification or immobilization processes. Our results apply specifically to these soils and conditions, so more work is needed for reliable interpretations.

적　　요

토양에 시용되는 각종 폐유기물들의 토양중 질소 무기화율을 알아보기 위하여 3종의 폐유기물(A:도시고형

폐기물+하수슬러지, B:목재잔사, C:목재잔사+하수슬러지)를 토양에 처리한 뒤 12주 동안 25℃ 호기조건에서 질소 무기화율을 조사한 결과, 초기 질산화율은 C 처리구가 다른 처리구에 비하여 높았다. 또한 무기화된 총질소량은 C 처리구에서 가장 많았으나 실험기간 동안의 질소 무기화율과 질산화율은 무처리구에서 높게 나타났다.

Acknowledgements

Thanks are extended to Dawn E. Lucas for her help in the laboratory. This research was conducted as a part of International Atomic Energy Agency(IAEA) Fellowship (ROK/96007P).

References

Bernal, M. P., and H. Kirchmann. 1992. Carbon and nitrogen mineralization and ammonia volatilization from fresh, aerobically and anaerobically treated pig manure during incubation with soil. Bio. Fertil. Soils. 13:135-141.

Binkley, D. 1984. Ion exchange resin bags: Factors affecting estimates of nitrogen availability. Soil Sci. Soc. Am. J. 48:1181-1184.

Binkley, D., and P. Matson. 1983. Ion exchange resin bag method for assessing forest soil nitrogen availability. Soil Sci. Soc. Am. J. 47:1050-1052.

DiStefano, J. F., and H. L. Gholz. 1986. A proposed use of ion exchange resins to measure nitrogen mineralization and nitrification in intact soil cores. Soil Sci. Plant Anal. 17:989-998.

Douglas, B. F., and F. R. Magdoff. 1991. An evaluation of nitrogen mineralization indices for organic residues. J. Environ. Qual. 20:368-372.

Keeney, D. R., K. W. Lee, and L. M. Walsh. 1975. Guidelines for the application of wastewater sludge to agricultural land in Wisconsin. Tech. Bull. 88. Wisconsin DNR, Madison, WI.

King, L. D. Availability of nitrogen in municipal, industrial, and animal wastes. J. Environ. Qual. 13:609-612.

Laanbroek, H. J., and S. Gerards. 1991. Effects of organic manure on nitrification in arable soils. Biol. Fertil. Soils. 12:147-153.

Nadelhoffer, K. J. 1990. Microlysimeter for measuring nitrogen mineralization and microbial respiration in aerobic soil incubations. Soil Sci. Soc. Am. J. 54:411-415.

Parker, C. F., And L. E. Sommers. 1983. Mineralization of nitrogen in sewage sludge. J. Environ. Qual. 12:150-156.

Sabey, B. R., N. N. Agbim, and D. C. Markstrom. 1975. Land application of sewage sludge: II. Nitrate accumulation and wheat growth resulting from the addition of sewage sludge and wood waste to soils. J. Environ. Qual. 4:383-393.

Schnabel, R. R. 1983. Measuring nitrogen leaching with ion exchange resin: A laboratory assessment. Soil Sci. Soc. Am. J. 47:1041-1042.

Spalding, R. F., and M. E. Exner. 1993. Occurrence of nitrate in groundwater-A review. J. Environ. Qual. 22:392-402.

Subler, S., J. M. Blair, and C. A. Edwards. 1995. Using anion-exchange membranes to measure soil nitrate availability and net nitrification. Soil Biol. Biochem. 27:911-917.

Wiseman, J. T., and L. M. Zibilske. 1988. Effects of sludge application sequence on carbon and nitrogen mineralization in soil. J. Environ. Qual. 17:334-339.