

EFFECT OF LIMING, PHOSPHORUS AND AMMONIUM SULPHATE ON AMMONIFICATION AND NITRIFICATION IN PEAT

R. MANDAL AND J. W. PARSONS

Department of Soil Science, University of Aberdeen, AB9 2UE, Scotland, U.K.

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Mineralization of native N in an extremely acid peat following liming and addition of P and $(\text{NH}_4)_2\text{SO}_4$ was investigated. All the treatments increased $\text{NH}_4\text{-N}$ upto 20 days incubation followed by a rapid decrease to a minimum at 35 days. The trend, thereafter, mainly followed a slow increase at 45 days. Released of $\text{NH}_4\text{-N}$ increased significantly with pH and added $(\text{NH}_4)_2\text{SO}_4$ specially where lime and N were applied together.

The $(\text{NO}_2+\text{NO}_3)\text{-N}$ level dropped in the first 5 days and remained near zero upto 25 days of incubation in all the treatments. A subsequent small flush occurred at 35 days. Nitrification was limited allthrough. Neither lime nor $(\text{NH}_4)_2\text{SO}_4$ was effective in stimulating $(\text{NO}_2+\text{NO}_3)\text{-N}$ production. Added P did not promote ammonification and nitrification significantly. Interactions of lime, P and $(\text{NH}_4)_2\text{SO}_4$ were nonsignificant in both processes except ammonification of N x pH in peat.

Key words: Ammonification, Nitrification, Peat.

Introduction

The organic matter of the soil contains the major proportion of N and is the key factor in limiting the amounts of NH_4 and $\text{NO}_3\text{-N}$ released in soil. Mineralization of organic nitrogenous compounds is a biochemical phenomenon regulated by substrate and environmental conditions. The acidity of soil plays a vital role in this respect.

Nitrifying organisms are sensitive to soil pH and the individual Genera have different pH optima. The optima for most common strains of *Nitrosomonas* fall in the range between 7 and 9 and that of *Nitrobacter* is 5-10 [1]. Nevertheless, the activity of nitrifiers has been observed in mineral soils even at pH values below 4 [2,3]. Studies on N transformation as influenced by pH have been mainly on mineral soils [4,5]. Commonly liming improved the mineralization of N in soils significantly.

Release of mineral N in organic soil/peat was studied only by a few workers [6-8] and this field deserves further investigation to improve the N economy by exploiting the native N particularly in agriculturally important organic soils. The present study reports an attempt to evaluate the impact of lime, $(\text{NH}_4)_2\text{SO}_4$ and P as microbial stimulant of ammonification and nitrification in a highly acid peat.

Materials and Methods

Materials. The peat sample was collected from Red Moss site near Aberdeen, air-dried and ground to pass through 2 mm sieve. The peat containing 76.6% organic matter was high in C/N ratio and became extremely hard following air-drying (Table 1). Moreover, the sample was also extremely acidic in nature, low in available P and $(\text{NO}_2+\text{NO}_3)\text{-N}$, and moderate in $\text{NH}_4\text{-N}$ and CEC.

Incubation technique. The peat sample was incubated at three pH levels with three levels of P and two levels of N in a full factorial combination with two replications arranged in a randomized block design.

$\text{Ca}(\text{OH})_2$ at the rate of 0, 13.3 and 26.9 g kg^{-1} was applied to change the initial pH from 3.4-4.5 and 5.5 respectively. A solution of $(\text{NH}_4)_2\text{SO}_4$ was applied at the rate of 0 and 100 mg N kg^{-1} and a solution of $\text{CaH}_4(\text{PO}_4)_2 \cdot \text{H}_2\text{O}$ to provide 0, 50 and 100 mg P kg^{-1} peat. A basal dose of soil infusion (10 ml kg^{-1} peat) was also included in the experiment to stimulate nitrification in peat. This infusion was prepared from a garden soil and water in the ratio 1:2.5.

200 g air-dry peat (2 mm) was weighed into a series of 36 clean-dry 500 ml conical flask. Taking the quantity of the added solutions into account, the peat samples were each

TABLE 1. GENERAL CHARACTERISTICS OF THE PEAT EXAMINED (MEANS OF DUPLICATE ANALYSES).

WHC Peat	Organic	Total matter	C/N	pH	CEC	Available	Available		P mg kg^{-1} peat
							meq kg^{-1} peat	N mg kg^{-1} peat	
		Percent	N	ratio			$\text{NH}_4\text{-N}(\text{NO}_2+\text{NO}_3)\text{-N}$		
Red moss	219	76.6	1.22	36.5	3.4	816	122	6.6	15.8

adjusted to 50% water holding capacity (WHC) and incubated at 25° with parafilm covering. Each day the covering was removed for 5 minutes for aeration and for the moisture content to be maintained constant gravimetrically. About 5 g peat was sampled from each flask every 5 days upto 45 days to determine $\text{NH}_4\text{-N}$ and $(\text{NO}_2+\text{NO}_3)\text{-N}$. pH was measured in separate 5 g peat.

Analytical techniques. pH was measured from a saturation paste using a combined glass/calomel electrode. Organic carbon was measured by wet oxidation method [9]. Estimations were made of total N by kjeldahl digestion and CEC by 1M NH_4OAc (pH 7.0). Available $\text{NH}_4\text{-N}$ and $(\text{NO}_2+\text{NO}_3)\text{-N}$ were determined colorimetrically in 2M KCl extract using a Technicon Auto-Analyzer [10]. Available P in 0.5M acetic acid [11] extract was measured spectrophotometrically using a Cecil Spectrophotometer (Model E 272).

Test for nitrifiers. 20 g air-dry garden soil (2 mm) was incubated in 50 ml conical flask in the absence and presence of 10 mg N kg^{-1} as $(\text{NH}_4)_2\text{SO}_4$ at 50% WHC and 25° for 7 days. Potentiality of nitrifiers was confirmed by significant accumulation of $(\text{NO}_2+\text{NO}_3)\text{-N}$.

Results

Release of $\text{NH}_4\text{-N}$ and $(\text{NO}_2+\text{NO}_3)\text{-N}$ from peat in the presence and absence of N due to liming and P addition have been measured and presented as mean of duplicates in Fig.1. Because the statistical LSD at 1% level indicates that only pH has significant effects on the $\text{NH}_4\text{-N}$ recoveries these 3D diagrams were plotted from the means of the results for the 0,50 and 100 mg levels of P for each pH/day.

All the treatments caused an increase in $\text{NH}_4\text{-N}$ upto 20 days of incubation with a significant immobilization at 15 days (Fig.1). Accumulation of $\text{NH}_4\text{-N}$ than followed an alternate release and immobilization. Release of $\text{NH}_4\text{-N}$ was significantly higher at pH levels 4.5 and 5.5 over the control. Application of P increased the release of $\text{NH}_4\text{-N}$ but not significantly. Similar positive effect of P was observed when applied inconjunction with lime or N at any level (50 or 100 mg P kg^{-1}). However, when N was applied a very distinct and significant stimulation in the release of $\text{NH}_4\text{-N}$ was recorded alone and in combination with lime. The interactions of lime, P and N though increased the accumulation of $\text{NH}_4\text{-N}$ but not significantly. Maximum amount of $\text{NH}_4\text{-N}$ accumulated was 595 mg kg^{-1} at 20 days when the peat was incubated with N and 100 mg P kg^{-1} . During peak period of ammonification (10 to 25 days) addition of N stimulated the activity of ammonifiers very promisingly with an accumulation of more than net 100 mg $\text{NH}_4\text{-N kg}^{-1}$ peat in all the treatments over those receiving no N. At day 45, the treatments with N yielded slightly higher

amount of $\text{NH}_4\text{-N}$ at lower pH except at pH 5.5 with 50 mg P kg^{-1} .

Release of $(\text{NO}_2+\text{NO}_3)\text{-N}$ showed an unusual trend (Fig.1). The initial $(\text{NO}_2+\text{NO}_3)\text{-N}$ level dropped in the first 5 days in all the treatments and continued upto 25 days of incubation. This disappearance of $\text{NO}_3\text{-N}$ might be due to denitrification of N favoured by high organic matter content of the peat. The $(\text{NO}_2+\text{NO}_3)\text{-N}$ levels were very low and showed only a sudden "mini-flush" at 35 days corresponding to the minimum levels of $\text{NH}_4\text{-N}$. The concentration of $(\text{NO}_2+\text{NO}_3)\text{-N}$ again started to decline until day 40. At 45 days, peat incubated at higher pH showed a little generation of $(\text{NO}_2+\text{NO}_3)\text{-N}$. Among the treatments pH in all combinations

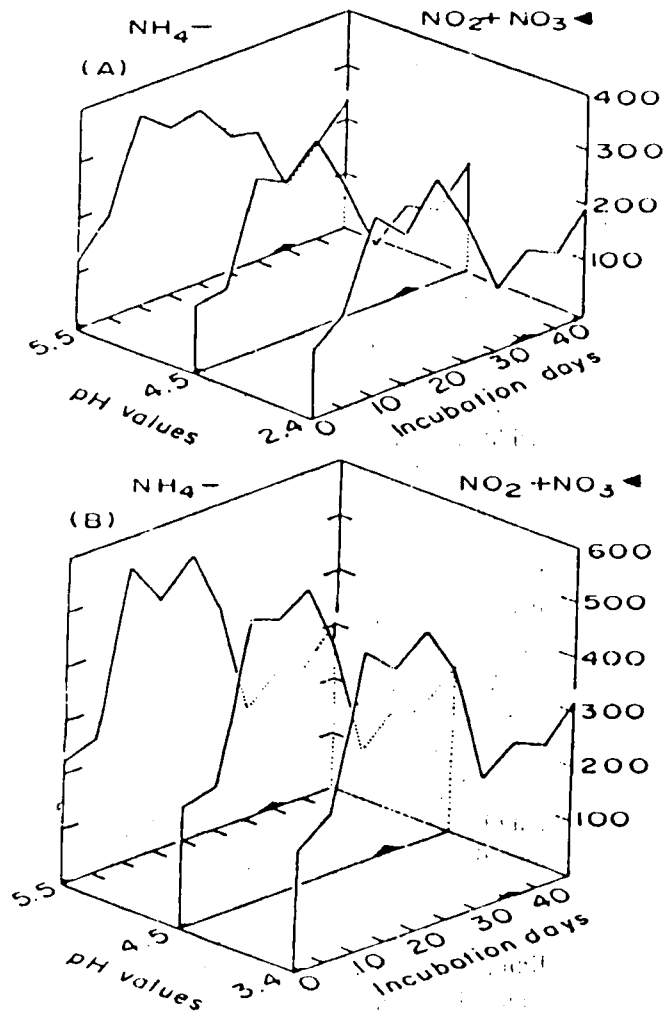


Fig. 1. Recovery of mineral N (mg kg^{-1} dry peat) from peat incubated without $(\text{NH}_4)_2\text{SO}_4$ (A) and with $(\text{NH}_4)_2\text{SO}_4$ (B) aerobically at 25°.

LSD at 1% level: 6.8, 2.8, 4.9, 6.7, 5.2, 2.9, 3.2, 4.1, 2.5, for pH; 3.8, 4.9, 5.4, 4.6, 3.9, 4.8, 2.8, 2.3, 3.0, for N; 2.1, 3.6, 4.1, 2.9, 6.2, 5.8, 3.4, 4.6, 3.3 for N x pH at 5, 10, 15, 20, 25, 30, 35, 40, and 45 days respectively. Incubation period: 11, 23,

showed slightly better formation of $(\text{NO}_2 + \text{NO}_3)\text{-N}$ at 35 and 45 days of incubation. In contrast, pH 5.5 at any combinations showed slight suppression of nitrification.

pH in all the treatments decreased nonsignificantly except those receiving no lime which showed slight increase at the latest part of incubation.

Discussion

Application of lime increased the process of ammonification significantly. The profound impact of lime on ammonification was also reported by Kaila [6] and Harmsen and Van Schreven [7]. The recovery of $\text{NH}_4\text{-N}$ was significantly greater in peat treated with lime together with $(\text{NH}_4)_2\text{SO}_4$ than lime alone. Addition of soluble N promoted the release of $\text{NH}_4\text{-N}$ from the peat by encouraging the growth and activity of ammonifiers. P possibly got fixed in peat and became ineffective to promote the release of $\text{NH}_4\text{-N}$ significantly.

Nitrification occurred after a lag phase of 30 days. Similar views were also expressed by Ishaque and Cornfield [12] and Tan [13] who observed that nitrification may proceed following a lag period in highly acid soils. Evidences suggest that liming generally stimulated nitrification in soil [8,14,15]. However, a contrasting result was found in this experiment. Too abrupt and too drastic liming might cause temporary destruction of microbial activity and mineralization of N in soil [16].

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References

1. M. Alexander, *In: Soil Nitrogen*, Agronomy 10 (ed. W.V. Bartholomew and F.E. Clark, Amer. Soc. Agron., Madison, USA, 1965), pp. 307-343.
2. M. Alexander, *Introduction to Soil Microbiology* (John Wiley and Sons. Inc., New York and London, 1976), pp. 467.
3. D.F. Weber and P.L. Gainey, *Soil Sci.*, **94**, 138 (1962).
4. P.C. Pang, C.R.A. Hedling and C.M. Cho, *Can. J. Soil Sci.*, **53**, 331 (1973).
5. P.C. Pang, C.M. Cho and R.A. Hedling, *Can. J. Soil Sci.*, **55**, 15 (1975).
6. A. Kaila, *Acta Agricultural Scandinavica*, **4**, 17 (1954).
7. G.W. Harmsen and D.A. Van Schreven, *Advan. Agron.*, **7**, 299 (1955).
8. R. Mandal and J.W. Parsons, *Dhaka Univ. Stud., Part E*, **4** (1), 1 (1989).
9. J. Tinsley, *A Manual of Experiments* (Department of Soil Science, University of Aberdeen, Scotland, UK, 1970).
10. F.A.J. Armstrong, C.R. Sterns and J.D.H. Strickland, *Deep-Sea Res.*, **14**, 381 (1967).
11. E.G. Williams and A.B. Stewart, *J. Soc. Chem. Indust.*, **60**, 291 (1941).
12. M. Ishaque and A.H. Cornfield, *Plant and Soil*, **37**, 91 (1972).
13. K.H. Tan, *Proceedings, Conference on Chemistry and Fertility of Tropical Soils*, Kuala Lumpur, Malaysia, 130-135 (1973).
14. J.W. Robinson, *Plant and Soil*, **19**, 173 (1963).
15. P.R. Sabej and D.D. Johnson, *Soil Sci. Soc. Amer. Proc* **35**, 848 (1971).
16. J.W. Lipman, P.E. Brown and J.L. Owen (New Jersey Agricultural Experiment Station, 30th Annual Report, 117-180 (1909).