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INFLUENCE OF LIME AND SOIL INFUSION TREATMENTS ON NITRIFICATION OF NATIVE AND ADDED AMMONIUM-NITROGEN IN PEAT

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Abstract

Nitrification under acid conditions in peat was studied. Application of lime increased nitrification in commercial peat. Release of mineral nitrogen increased rapidly with pH. A significant amount of NH_4-N was released up to 40 days of incubation followed by a rapid decline with the accumulation of $(NO_2+NO_3)-N$ with time. In contrast, liming had little or no effect on nitrification in Red Moss peat. Only after a long lag period of 24 days, a sudden flush in NO_2+NO_3-N (0.5—1.6 to 28.5—35.0 $\mu g\ g^{-1}$) occurred in all the treatments. Soil infusion showed no significant additive effect on nitrogen release. Results provide evidence that nitrification can proceed at low pH (3.4 to 4.0) where an acid-adapted strain may be active.

Introduction

The marked influence of soil reaction on transformation of organic nitrogen and particularly on nitrification have already been recognized (Alexander 1965, Meek and Lipman 1922, Kaila 1954, Kaja 1963, Weber and Gainey 1962, Sabey and Johnson 1971, Pang *et al.* 1973). However, the study of nitrification in acid soils is still of great interest. Liming acid soil usually stimulates the activity of ammonifiers and nitrifiers by achieving dual functions, namely, by reducing acidity and by providing calcium. Nitrification is reported to occur over a wide range of pH from very low, 3.7 (Olsen 1929), up to about 13.0 (Meek and Lipman 1922), although the rate is slower at extreme values and increases as the soil approaches neutrality.

Peats contain an appreciable proportion of total nitrogen but conversion of this to inorganic nitrogen is generally slow at low pH. Two acid peats were selected to evaluate the influence of lime on the extent of nitrification. Since the peats were acid, inclusion of a soil infusion would be a logical approach to be sure of nitrification.

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Materials and Methods

Red Moss and commercial peat were incubated separately with three levels of lime in the presence and absence of a soil infusion. Red Moss peat did not receive any added NH_4-N since its initial NH_4-N content was high (105.6 μg^{-1} peat, Table 1). Ca $(0H)_2$ was applied to raise the pH to 4.5 and 5.5. The amount of Ca $(OH)_2$ required was calculated from the pH titration curves. Samples of 10 g peat were mixed separately with 0, 0.2, 0.4, 0.6, 0.8 and 1.0 g of $Ca(OH)_2$ and the pH was measured from the saturation paste. The pH titration curve was plotted with pH against amount of $Ca(OH)_2$. Commercial peat was incubated with the addition of $(NH_4)_2 SO_4$ at the rate of 0 and 100 μg N g^{-1}. Its pH was modified to 5.5 and 6.5. For both peats, the level of infusion was 0 and 1 ml 100 g^{-1} peat. The treatments were arranged according to a randomized block design with two replications.

Table 1. General characteristics of the peats examined

Peat	pH	WHC	Org. C	Total N	CEC* meq kg^{-1} peat	Available N ($\mu g\ g^{-1}$ peat)	
		Per cent				NH_4-N	(NO_2+NO_3)-N
Commercial	4.38	259	41.41	1.53	902.2	17.00	186.50
Red Moss	3.40	219	44.56	1.22	816.2	105.60	6.93

*cation exchange capacity

Portions of air-dried (2 mm) sample (100 g) were weighed into a series of clean-dry 500 ml Erlenmeyer flasks and incubated at 50% water holding capacity (WHC) at 25°C with clingfilm covering. A constant moisture content was maintained gravimetrically all through and aerated every day by removing the clingfilm cover for 5 min.

Samples were collected after every 10 days over 100 days from commercial peat and 3 days over 27 days from Red Moss peat from incubation. Change in mineral nitrogen and pH at the end were determined.

pH was measured from a saturation paste by using a model 7020 pH meter. The procedures outlined by Tinsley (1970) were employed for the determination of organic carbon by wet oxidation, total N by Kjeldahl digestion and CEC by 1 M NH_4OAc, pH 7.0. Ammonium - nitrogen NH_4–N and (NO_2+NO_3)–N extracted with 2M KCl were determined spectrophotometrically by reading, respectively, at 660 nm and 520 nm (Armstrong *et al.* 1967).

Test for nitrifiers. A small portion, 20 g, 2 mm, of garden soil was incubated with and without 10 μg NH_4-N g^{-1} at 50% WHC for 7 days. Accumulation of significant amount of (NO_2+NO_3)-N (14-47 μg g^{-1}) indicated the presence of potential nitrifiers in the soil sample.

Results and Discussion

Changes in NH_4-N and (NO_2+NO_3)-N following liming of peats have been observed (Tables 2 and 3).

Addition of lime showed a pronounced impact on mineral nitrogen change in commercial peat. Liming released significatly higher amounts of mineral nitrogen from humus nitrogen as compared to untreated samples (Table 2). Harmsen and Van Schreven (1955) clearly demonstrated the profound effect of pH on nitrogen mineralizatian and observed that nitrification can be considerably acclerated by application of lime. A substantial amount of NH_4-N was produced up to 40 days. Thereafter, it declined very rapidly with accumulation of (NO_2+NO_3)-N with time. Almost no change occurred from 40-70 days of incubation and after 70 days, a very slow nonsignificant positive change was observed in all the treatments.

Nitrification was very distinctly and significantly stimulated by liming (Table 2). Increase in pH by liming increased accumulation of (NO_2+NO_3)-N with an initial and final increase with a depression between 40-50 days of incubation. A total amount of 351 μg (NO_2+NO_3)-N g^{-1} was recorded after 100 days of incubation, but the value reached to 423 and 464 μg g^{-1} when the pH was raised to 5.5 and 6.5, respectively. The pattern ot nitrification was very similar in both the lime treated and untreated samples and even in the presence of added $(NH_4)_2SO_4$, the trend remained almost unchanged. Soil infusion showed no beneficial effect on mineral nitiogen release.

A contrasting and interesting result was found in Red Moss peat (Table 3). Instead of release, the amount of NH_4-N decreased with increasing pH (Table 3). Accumulation of NH_4-N was irregular at pH 5.5. Nevertheless, the recovery was the lowest. This might be due to immobilization of NH_4-N by microorganisms. A reasonably sharp increase in NH_4-N from 84-166 to 125-218 μg g^{-1} occurred between 21 and 24 days in all the treatments. Soil infusion was only effective at pH 5.5 to expedite ammonication.

Table 2. Influence of lime and soii infusion on recovery of NH_4-N and (NO_2+NO_3)-N $\mu g\ g^{-1}$ dry peat from commercial peat incubated with ammoniumsulfate aerobically at 25°C.

Soil infusion	No infusion					
N($\mu g\ g^{-1}$ peat)	O			100		
pH	4.38	5.50	6.50	4.38	5.50	6.50
Days of incubation						
0	18	19	19	120	119	116
	(216)	(215)	(216)	(216)	(215)	(212)
10	51	45	71	154	104	137
	(232)	(275)	(285)	(242)	(309)	(284)
20	88	81	82	173	70	77
	(307)	(372)	(410)	(340)	(448)	(476)
30	85	72	85	109	78	62
	(347)	(400)	(449)	(416)	(490)	(503)
40	79	99	93	75	76	80
	(336)	(410)	(449)	(427)	(480)	(513)
50	19	20	18	18	17	21
	(294)	(348)	(393)	(392)	(439)	(472)
60	18	19	20	18	20	20
	(307)	(368)	(407)	(405)	(459)	(488)
70	7	7	7	6	7	8
	(324)	(369)	(414)	(406)	(464)	(481)
80	8	10	10	8	9	11
	(330)	(401)	(436)	(428)	(494)	(516)
90	8	7	9	8	8	9
	(339)	(403)	(441)	(424)	(493)	(506)
100	7	10	8	7	10	8
	(351)	(423)	(464)	(443)	(499)	(518)

Figure in the parenthesis represents (NO_2+NO_3)-N.
Figure not in the parenthesis represnets NH_4-N.

All the treatments showed an initial immobilization of (NO_2+NO_3)-N (Table 3). After a long lag period, nitrification occurred (at 24 days) for a short period of time but again instead of continuing, the process declined. This suggests that nitrifiers may be heterotrophs or acid-adapted strains of autotrophs. Evidence from other sources suggests that in highly acid soils, nitrification may occur following a lag period (Ishaque and Cornfield 1972,

Table 2. (Continued)

Soil infusion	Plus infusion						
N(μg g⁻¹ peat)	0			100			LSD
pH	4.38	5.50	6.50	4.38	5.50	6.50	at
Days of incubation							1%
0	17	19	20	121	119	116	1.86
	(214)	(216)	(216)	(216)	(214)	(215)	(NS)
10	56	45	59	155	106	132	7.52
	(236)	(278)	(283)	(245)	(307)	(299)	(5.49)
20	94	67	77	175	58	65	20.16
	(317)	(353)	(403)	(345)	(443)	(467)	(16.93)
30	78	82	83	111	59	80	12.70
	(353)	(393)	(447)	(418)	(471)	(515)	(23.51)
40	83	75	100	83	81	94	NS
	(351)	(382)	(455)	(430)	(465)	(533)	(26.21)
50	18	21	19	17	19	19	NS
	(302)	(337)	(392)	(389)	(427)	(467)	(12.21)
60	16	18	19	18	20	21	NS
	(312)	(360)	(405)	(399)	(453)	(492)	(16.12)
70	6	7	8	6	8	7	NS
	(318)	(353)	(409)	(405)	(447)	(492)	(11.49)
80	9	9	9	9	9	10	NS
	(342)	(393)	(438)	(427)	(475)	(518)	(16.37)
90	6	8	9	7	8	6	NS
	(357)	(393)	(442)	(435)	(478)	(515)	(15.47)
100	8	8	9	7	10	9	NS
	(364)	(413)	(459)	(443)	(482)	(531)	(17.13)

Figure in the parenthesis represents (NO_2+NO_3)-N.
Figure not in the parenthesis represents NH_4-N.

Tan 1973). Nevertheless, Lipman *et al.* (1909) observed that too abrupt and too drastic liming may cause temporary destruction of microbial activity and the mineralization process in soil.

Nitrification of added $(NH_4)_2SO_4$ occurred in the commercial peat samples used but the Red Moss peat, because of its high C/N ratio, 36.5, caused immobilization of inorganic nitrogen when incubated, rather than nitrification even when lime and a soil infusion were added.

Table 3. **Influence of lime and soil influsion on recovery of NH_4-N $\mu g\ g^{-1}$ dry peat during aerobic incubation of Red Moss peat at 25°C**

Days of incubation	No infusion			Plus infusion			LSD at 1%
	pH			pH			
	3.4	4.5	5.5	3.4	4.5	5.5	
0	113	120	107	108	119	111	15.12
	(8.8)	(8.8)	(8.8)	(8.1)	(7.6)	(8.4)	*
3	133	111	98	133	115	84	12.39
	(3.1)	(3.7)	(0.2)	(bdl)	(3.7)	(0.2)	*
6	131	109	103	126	111	113	6.37
	(bdl)	(0.6)	(0.3)	(0.1)	(0 3)	(0.5)	*
9	137	120	99	138	122	119	13.60
	(0.1)	(0.6)	(0.4)	(0.3)	(0.5)	(0.5)	*
12	139	116	78	135	129	133	11.49
	(bdl)	(0.6)	(0.6)	(bdl)	(0.8)	(0.2)	*
15	149	149	91	155	138	128	10.13
	(bdl)	(1.1)	(0.6)	(0.1)	(1.0)	(0.8)	*
18	156	161	82	136	152	124	19.66
	(bdl)	(1.4)	(0.4)	(bdl)	(1.3)	(0.6)	*
21	166	161	84	164	157	122	17.11
	(bdl)	(1.4)	(0.5)	(bdl)	(1.6)	(0.6)	*
24	212	213	125	218	213	174	20.81
	(28.5)	(31.4)	(33.3)	(31.5)	(31.9)	(35.0)	*
27	215	223	118	209	229	175	21.64
	(26.6)	(25.9)	(29.7)	(27.0)	(28.7)	(33.0)	*

bdl = below detection limit. Figure in the parenthesis represents (NO_2+NO_3)-N. Figure not in the parenthesis represents NH_4-N.
*Not calculated.

A general decrease in pH was observed in commercial peat ranging from 0.14 to 0.72 unit after 100 days of incubation over the control. The extent of decrease progressed with pH and direct bearing upon oxidation of NH_4-N to accumulation of (NO_2+NO_3)-N. However, in Red Moss peat, the of pH was reduced by between 0.20 and 0.47 over the control after 27 days incubation and only from limed samples.

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