Bangladesh J. Sci. Res. 6 (1 & 2), 1988 : 23-28

EFFECT OF ADDITION OF VARYING LEVELS OF SODIUM AS CHLORIDE AND SULPHATE ON NITROGEN MINERALIZATION DURING AEROBIC INCUBATION OF TWO BANGLADESH SOILS

M. S. CHOWDHURY AND S. M. IMAMUL HUQ

Department of Soil Science, Dhaka University, Bangladesh.

Abstract

The effects of addition of 0.1, 0.25, 0.50 and 1.00% NaCl and equivalent levels of Na^+ as Na_2SO_4 on N-mineralization and nitrification were studied after 6 weeks of aerobic incubation of Fatki series soil (F-soil, pH 7.6) and Tejgaon series soil (T-soil, pH 4.9).

In the F-soil, N-mineralization was not affected by 0.1% NaCl, was decreased by 0.25% and was stopped by 0.50 and 1.00% levels; nitrification decreased with increasing NaCl, but did not completely stop even at 1.00%. In the equivalent sulphate series, N-mineralization and nitrification were not affected by 0.1 to 0.5% levels, the 1.00% level however, moderately depressed both the processes.

In the T-soil, N-mineralization was not affected by any level of NaCl; nitrification was greatly affected by 0.1% NaCl and stopped by the higher levels. In the equivalent sulphate series, N-mineralization was not affected by 0.1 to 0.5% levels but was increased somewhat at 1.00%; nitrification declined considerably with increased sulphate to 0.25% and was stopped by the higher levels.

Introduction

Lipman (1) was probably the first to show that addition of soluble salts to soils affected N-mineralization. Greaves (2) found that soil texture and moisture content influenced the relative toxicity of added salts. Brown and Hitchcock (3) and Sindhu and Cornfield (4) found that low concentrations of some salts stimulated nitrification though the process being inhibited at higher concentrations of the salts.

The present work reports on the effects of adding varying levels of Na^+ as chloride and sulphate on N-mineralization and nitrification during aerobic incubation of a slightly alkaline and an acid soil of Bangladesh.

Material and Methods

Samples of soils representing two soil series were selected for the study. These series include the Fatki and Tejgaon. Samples of the two soils were collected from the top 25 cm over several acres. The Fatki series soil is designated as F-soil and the Tejgaon series soil as T-soil in the text. The composite samples were air dried and passed through a 1mm sieve.

The F-soil had a pH of 7.6 (soil : water ratio 1 : 2.5) and contained 24% clay, 38% silt, 38% sand, 0.55% organic carbon, 0.081% total-N, 41.8 ppm ammonium-N and 11.2 ppm nitrate-N. The T-soil had a pH of 4.9 and contained 26% clay, 22% silt, 52% sand, 0.55% organic carbon, 0.069% total-N, 101.4 ppm ammonium-N and 4.0 ppm nitrate-N.

Bulk quantities of both soil types were mixed with finely ground NaCl to supply 0.1, 0.25, 0.5 and 1.0% levels of Na^+ on the dry soil basis. Further quantities of both soils were mixed with finely ground Na_2SO_4 to supply the same levels of Na^+ as in the chloride series, 10 g portions of each treatment and control (no added Na^+) were set up in triplicate in 10 cm × 2.5 cm diameter glass tubes and was added to 50% saturation (an aeroble moisture content). The barium peroxide method (5) was used for aeration and absorption of CO_2 during incubation (30°C) of the tubes, which were closed with rubber bungs. After incubation (6 weeks) the soils were shaken with 10 ml water and the pH and the Ec of the suspensions determined. Then 10 ml of 2N KCl was added and after vigorous shaking the tubes were centrifuged. The supernatant liquid was analysed for ammonium- and nitrate-N by microdiffusion method (6).

Results

Results in Tables I (a, b) and II (a, b) show accumulation values (obtained by substracting initial values from those after incubation) for ammonium-N, nitrate-N and mineral-N (ammonium-N+nitrate-N) as affected by different rates of Na^+ as NaCl and Na_2SO_4 salts. Negative values of each form of mineral-N indicate decrease due to incubation. Ec and pH values of the aqueous suspension after incubation are also presented.

Nitrification (nitrate accumulation) in the F-soil was not affected by 0.1% NaCl, while in the T-soil it was reduced considerably (more than 84% decrease). Although rate of nitrification declined further with increasing rates of NaCl in the F-soil, yet there was slight nitrification even at 1.0% NaCl (ca. 8% of original). In the T-soil however, nitrification was stopped by 0.25% and higher levels of NaCl. N-mineralization (ammonium- +nitrate-N accumulation) in the F-soil was not affected by 0.1% NaCl, was almost halved by 0.25% NaCl and was stopped by 0.4 and 1.0% NaCl. In the T-soil, N-mineralization was not significantly affected by any level of NaCl.

Table I. Effects of varying levels sf Na^+ as NaCl on mineral nitrogen accumulation during aerobic incubation of Fatki (a) and Tejgaon (b) series soils.

% Na^+ as NaCl	NH_4-N ppm	NO_3-N ppm	Mineral-N ppm	pH	Ec mS
(a)					
0	−40.8	77.1	36.6	7.7	1.10
0.10	−40.8	75.2	34.4	7.7	1.95
0.25	−40.2	58.2	18.2	7.6	3.10
0.50	−35.5	31.2	−4.3	7.7	4.90
1.00	−20.8	6.4	−14.4	7.7	8.50
(b)					
0	−31.4	57.6	26.2	4.4	0.50
0.10	14.3	9.2	23.5	4.8	1.35
0.25	24.9	−0.6	24.3	4.8	2.70
0.50	26.3	−0.6	25.7	4.8	5.00
1.00	25.2	−1.7	23.5	4.8	9.50
L.S.D. P 0.05	2.1	3.0	3.3		

Negative values inducate less of each mineral-N form after incubation than initial.

Table II. Effects of varying levels of Na^+ applied as Na_2SO_4 on mineral nitrogen accumulation during aerobic incubation of Fatki (a) and Tejgaon (b) series soils.

% Na^+ as Na_2SO_4	NH_4-N ppm	NO_3-N ppm	Mineral-N ppm	pH	Ec mS
(a)					
0	−40.8	77.1	36.3	7.7	1.10
0.10	−41.2	78.1	37.2	7.7	1.80
0.25	−41.3	78.0	36.7	7.7	2.70
0.50	−41.2	75.6	34.4	7.7	4.00
1.00	−41.2	67.5	26.3	7.7	6.00
(b)					
0	−31.4	57.6	26.2	4.4	0.50
0.10	−20.2	43.1	22.9	4.7	1.15
0.25	5.6	20.1	25.7	4.8	2.40
0.50	24.1	2.7	26.8	5.1	4.10
1.00	36.8	−1.2	35.6	5.1	7.50
L.S.D. P 0.05	2.1	3.0	3.3		

Negative values indicate less of each mineral-N form after incubation than initial.

Comparison of the effects of Na_2SO_4 (Tables IIa, II b) levels on nitrification in the two soils show that the salt practically had no effect due to an application rate of 0.1 to 0.5% Na-equivalent as Na_2SO_4 and only a slight decrease due to 1.0% level in the F-soil while in the T-soil, the nitrification was reduced to more than 50% even at 0.25% Na-equivalent and being stopped beyond 0.5% level. N-mineralization in both soils was hardly affected by 0.1 to 0.5% Na-equivalents of Na_2SO_4. With the 1.0% level, N-mineralization was decreased in the F-soil (ca. 29%) but increased in the T-soil.

In the F-soil mineralized N accumulated entirely as nitrate with all levels of Na^+ as chloride and sulphate. In the T-soil, on the other hand, mineralized N accumulated entirely as ammonium with 0.25 to 1.0% levels of Na^+ as NaCl and 0.5 to 1.0% levels of Na^+ as Na_2SO_4.

Discussion

The generally higher toxicity of Na^+ as chloride than as sulphate in both soils suggests that it is the chloride rather than the associated cation which is the toxic factor to both nitrification and N-mineralization or alternatively, the toxic effect of excess Na^+ is a manifestation of the accompanying anion. The relatively low toxicity of sulphate compared to chloride, particularly at higher levels of Na^+, is probably due to the ability of the microbial cells to metabolise much of the sulphate absorbed thus preventing damage from plasmolysis. Negligible metabolism of chloride occurs in cells, thus it accumulates to a level where plasmolysis could occur.

From a different study with the T-soil (7) it is gathered that a heterotrophic rather than the more usual autotrophic process was responsible for nitrification. The high accumulation of nitrate (57.6 ppm N) in the control soil even at a pH 4.4 probably precluded the activity of the usual autotrophic nitrifiers (unless acid-adapted strains of autotrophic nitrifiers had evolved in this soil, but there was no evidence for this). The great decrease in nitrification due to even 0.1% NaCl and complete inhibition with 0.25% NaCl compared with only a moderate decrease in nitrification in the F-soil suggests that the presumed heterotrophic nitrifiers in the T-soil are particularly susceptible to even low levels of NaCl. It has been shown that several heterotrophs including actinomycetes, fungi and bacteria isolated from soils are able to produce nitrate in suitable cultures containing only organic nitrogen sources as substrates (8,9,10). Evidence was obtained that an autotrophic nitrification process was responsible for nitrification in the F-soil (7).

The virtual absence of inhibition of N mineralization in the T-soil due to any level of applied Na^+ as chloride or sulphate indicates that the activity of the heterotrophic ammonifying organisms as a whole was hardly affected. Alternatively some types may have been affected while other types became relatively more active in competition for the substrate. The increase in N-mineralization due to 1.0% Na^+ equivalent of Na_2SO_4 in the T-soil may have been due to the death of the more susceptible heterotrophs early in incubation followed later in incubation by increased activity of other types of heterotrophs, which survived this level of Na_2SO_4, resulting in production of extra ammonium-N by the end of incubation.

In comparison with the control soil the pH levels of the F-soil were slightly affected during incubation (not greater than 0.1 unit) by addition of NaCl or Na_2SO_4 at all levels. In the T-soil, on the other hand, pH was increased by 0.4 units by addition of NaCl at all levels of application while for Na_2SO_4 application, the increases were by 0.3 to 0.7 units. It is considered that these increases in pH were unlikely in themselves to have much effect on N-mineralization and nitrification. In any case, an increase in pH would tend to increase the activity of both processes and this might account for the only treatment (1.0% Na^+ equivalent of Na_2SO_4) where N-mineralization was increased.

In the F-soil conductivity (Ec) values showed that N-mineralization was stopped at 4.9 mS (0.5% NaCl), while nitrification was decreased to about 60% at this salinity level. Where 1.0% Na^+ equivalent of Na_2SO_4 was added both processes were decreased by not more than 30% even at 6.0 mS. In the T-soil with NaCl, 2.7 mS stopped nitrification, but with N_2SO_4 (0.5%) it was stopped at 4.1 mS. N-mineralization was barely affected by even 9.5 mS of salinity level. The highest Na_2SO_4 level increased N-mineralization, but it is not considered that the electrical conductivity itself was responsible for this.

References

1. Lipman, C. B. 1911. Toxic effects of alkali salts on soil bacteria. Abstr. Centbl. Bakt. 32 : 58-64.
2. Greaves, J. E. 1916. Influence of salt on bactarial activity in soils. Soil Sci. 2: 443-448.
3. Brown, P.E. and Hitchcock, E.B. 1917. Effect of alkali salts on nitrification in soil. Soil Sci. 4: 207-229.
4. Sindhu, M.A, and Cornfield, A.H. 1967. Plant and Soil 27: 468-472.
5. Cornfield, A.H. 1961. A simple technique for detecting mineralization of carbon during incubation of soils treated with organic materials. Plant and Soil. 14 : 90-93.

6. Bremner, J.M. 1965. *Methods of soil analysis. Part* **2**. *Chemical and Microbiological Properties*. Agronomic Monograph, No. 9. Amer. Soc. Agron. Madison, Wisconsin, USA (Ed. C.A. Black).
7. Choudhury, M.S. and Imamul Huq, S.M. 1987. Mineralization of nitrogen and carbon during aerobic incubation of three soils of Bangladesh. Dhaka Univ. Stud. Part E. 2 (2) : 137-139.
8. Eyler, Jr, J.R. and Schmidt, E.L. 1959. A survey of heterotrophic microorganisms from soil for ability to form nitrate. J. Gen. Microbiol. 20:473-481.
9. Dunner, H.B. 1963. Nitrification by *Arthobacter globiformis*. Nature. 197 : 1127-1128.
10. Doxtader, K.G. and Alexander, M. 1966. Nitrification by heterotrophic soil microorganisms. Proc. Soil Sci. Soc. Amer. 30: 351-355.