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# UREA AND AMMONIUM SULFATE-NITROGEN TRANSFORMATION IN SOILS

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## Abstract

**Changes in mineral nitrogen during eight weeks of incubation in three soils of Bangladesh treated with 50 and 100 ppm nitrogen as urea and ammonium sulfate were studied. $NO_3$-N accumulation was highest (80.5 ppm) in the Gangetic alluvium soil treated with 100 ppm ammonium sulfate. Lowest accumulation of $NO_3$-N (12.6 ppm) was observed in the red acid soils of Tejgaon series after three weeks of incubation with 50 ppm urea. The coastal saline soils of Barguna contained more $NO_3$-N than that of Tejgaon series soil, but less than Gengetic alluvium soil. Transformation of most of the added urea and ammonium sulfate occurred during the first three weeks of incubation of all the three soils.**

## Introduction

Supplemental addition of nitrogenous fertilizers is a precondition for sustainable agriculture in the prevailing situation in Bangladesh. The application of urea and ammonium sulfate in upland and lowland conditions has several drawbacks. Considerable amount of urea and ammonium sulfate may be lost by various processes like ammonium volatilization, leaching etc. Part of the added ammonium nitrogen may be fixed in the layer lattice minerals (1). Information is therefore, necessary, regarding the transformation of nitrogenous fertilizers in Bangladesh soils. The present study was designed to see nitrogen transformation capacities of three representative soils of Bangladesh which were treated with 50 and 100 ppm, each of urea and ammonium sulfate.

## Materials and Methods

Three representative soil series were selected for the study. They were (1) the Ghior series (silty clay loam of the Gangetic alluvium), (2) the Tejgoan series (clay loam of Tejgaon red soil) and (3) the Jhalokathi series (silty clay coastal

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saline soil from Barguna). Samples of the three soils were collected from the top 25 cm. The three series are designated in the text as GI, TI and SA soils respectively. The soil samples were dried and passed through a 1 mm sieve. The required quantities of urea and ammonium sulfate were first mixed with water and then added to 500 g of soils to supply 50 and 100 ppm N on dry soil basis. The soils were incubated in containers and were analyzed at the start and at 3, 6 and 8 weeks incubation. The soils were maintained at the field capacity moisture level throughout the experimental period. All treatments as well as analyses were done in triplicate. After each incubation period, 10 g of soils were shaken with 10 ml portions of 2NKCl and 10 ml water and then filtered. The filtrate was analyzed for ammonium-N (2) and nitrate-N (3).

## Results and Discussion

Table 1 shows some physico-chemical characteristics of the soils under study and Table 2 shows mineral-N accumulation values obtained after each incubation period. Negative values indicate less of a particular mineral-N form after incubation than initially present.

**Table 1. Some physico-chemical characteristics of the soils under study.**

| Soil | % Clay | pH 1 : 2.5 | CEC m.e.% | O.C. % | Total N % | Total $P_2O$, % | Total $K_2$ O(%) | Ec $dSm^{-1}$ | $CaCO_3$ % |
|---|---|---|---|---|---|---|---|---|---|
| TI | 37.5 | 4.7 | 19.5 | 0.49 | 0.071 | 0.11 | 0.45 | n. d. | 0.24 |
| GI | 41.5 | 6.8 | 17.6 | 0.52 | 0.054 | 0.09 | 0.74 | n. d. | 3.92 |
| SA | 41.6 | 7.7 | 15.0 | 0.45 | 0.038 | 0.08 | 0.76 | 6.6 | 4.10 |

n. d. = not determined

Accumulation of $NO_3$-N in untreated soils was more in the GI than either TI or SA soils after 3 weeks of incubation. The accumulation of nitrate increased in all the soils during the subsequent periods of incubation. In any case, GI soil always showed the highest accumulation. After 8 weeks of incubation, GI soils accumulated about 34 ppm $NO_3$-N while in TI soils the value was about 24 and in the SA soils it was 26 ppm.

Only about 50 per cent of the added $NH_4$-N could be recovered immediately after addition of the fertilizers by KCl extraction from the GI and SA soils while the recovery rate from T1 soils was about 80 per cent. In GI soils, most of the nitrification occurred during the first 3 weeks of incubation. Nitrification was

faster in all soils during the earlier periods of incubation treated with 50 ppm as ammonium sulfate. With 100 ppm N as ammonium sulfate, a substantial amount of $NO_3$-N, however, accumulated during the later periods of incubation.

**Table 2. Mineral nitrogen accumulation (ppm on dry soils basis) (a) initial values (b) accumulation after incubation.**

(a)

| Soil | treatment | $NH_4$-N | $NO_3$-N | Min.-N |
|---|---|---|---|---|
| | Control | 9.0 | 4.7 | 13.7 |
| | AS50 | 35.9 | 4.0 | 39.9 |
| GI | AS100 | 52.4 | 4.7 | 57.1 |
| | U50 | 16.3 | 5.2 | 21.2 |
| | U100 | 14.3 | 4.9 | 19.2 |
| | Control | 14.9 | 3.5 | 18.4 |
| | AS50 | 58.2 | 3.4 | 61.6 |
| TI | AS100 | 94.3 | 4.3 | 98.6 |
| | U50 | 19.5 | 3.0 | 22.5 |
| | U100 | 18.3 | 3.7 | 22.0 |
| | Control | 12.0 | 4.1 | 16.1 |
| | AS50 | 33.7 | 4.3 | 38.0 |
| SA | AS100 | 58.6 | 4.6 | 63.2 |
| | U50 | 14.4 | 3.4 | 17.8 |
| | U100 | 18.7 | 2.7 | 21.4 |

AS = Ammonium sulphate ; U = Urea

Nitrification rate of added ammonium -N was slower in TI and SA soils than GI soils at all periods of incubation. A substantial amount of $NH_4$-N could be detected in those soils even after 8th week of incubation. On the other hand, insignificant increase in nitrate values was observed after 6 and 8 weeks of incubation in the GI soils. Between the TI and SA soils, hydrolysis of urea and its subsequent nitrification was faster in the latter soil. At the end of 8 weeks of incubation, some $NH_4$-N could still be detected in the TI soil.

It has already been mentioned that in GI and SA soils only about half and in TI soil over two third of the added $NH_4$-N was recovered at the start of incubation. This indicates the possibility of $NH_4$-N fixation in all the soils, even under wet condition. This could be due to the presence of vermiculite in the soil. It is known that vermiculite can fix native as well as added $NH_4$-N even under wet condition (2, 4). The lower fixation of ammonium in TI soils is due to lesser amount of vermiculite in this soil (5) and also because of low pH (pH 4.7), as fixa-

tion is known to decrease with increasing soil acidity (6, 7). In GI soils, most of the nitrification of the added ammonium sulfate and urea nitrogen accumulation was much greater than TI and SA soils. This suggests that the

**Table 2. Contd. (b).**

| Soils treatment | | 3 weeks incubation | | | 6 weeks incubation | | | 8 weeks incubation | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $NH_4$-N | $NO_3$-N | Min.-N | $NH_4$-N | $NO_3$-N | $Min_4$.-N | $NH_4$-N | $NO_3$-N | Min.-4N |
| GI | Control | - 6.0 | 17.8 | 11.2 | - 4.5 | 25.3 | 20.8 | - 4.2 | 33.8 | 29.9 |
| | AS50 | - 32.4 | 51.2 | 18.8 | - 32.9 | 56.1 | 23.2 | - 31.7 | 62.3 | 30.6 |
| | AS100 | - 47.0 | 63.6 | 16.6 | - 43.9 | 71.8 | 27.9 | - 45.9 | 80.5 | 34.6 |
| | U50 | - 9.0 | 53.5 | 44.5 | - 13.1 | 56.2 | 43.1 | - 11.3 | 60.2 | 48.9 |
| | U100 | - 10.3 | 70.1 | 59.8 | - 9.9 | 77.7 | 67.8 | - 7.7 | 75.6 | 67.9 |
| TI | Control | - 4.6 | 11.5 | 6.9 | - 3.9 | 16.8 | 12.9 | - 5.9 | 23.7 | 17.8 |
| | AS50 | - 16.7 | 19.9 | 3.2 | - 37.6 | 29.8 | -7.8 | - 41.6 | 36.5 | - 5.1 |
| | CAS100 | - 18.7 | 24.5 | 5.8 | - 35.7 | 33.8 | - 1.9 | - 44.4 | 38.0 | - 6.4 |
| | U50 | 14.1 | 12.6 | 26.7 | 10.2 | 21.7 | 31.9 | 17.4 | 18.2 | 35.6 |
| | U100 | 56.1 | 14.5 | 70.6 | 26.1 | 35.6 | 61.7 | 20.8 | 40.1 | 60.9 |
| SA | Control | - 7.8 | 14.7 | 6.9 | - 8.9 | 18.1 | 9.2 | - 8.0 | 26.2 | 18.2 |
| | AS50 | - 5.1 | 28.5 | 23.4 | - 10.3 | 35.2 | 24.9 | - 18.5 | 38.1 | 19.6 |
| | AS100 | - 15.0 | 33.5 | 18.5 | - 13.0 | 44.6 | 31.6 | - 10.5 | 60.7 | 40.6 |
| | U50 | 1.6 | 35.1 | 36.7 | - 6.2 | 42.7 | 36.5 | - 6.9 | 48.4 | 41.5 |
| | U100 | - 2.8 | 53.5 | 50.7 | - 6.1 | 56.2 | 50.1 | - 3.4 | 59.9 | 56.5 |

LSD P (0.05) NH4-N 2.5 $NO_3$-N 2.7, Min.-N 3.6

activity of the nitrifying organisms in the GI soils was greater than in the other soils. The pH of this soil also falls within the optimum range for nitrification. The lower activity of the nitrifying organisms in TI soils could be related to low pH. The pH of this soil is too low for the normal activity of nitrifying organisms. However, a fair proportion of mineral nitrogen accumulated as nitrate in this soil. This is possible when acid adapted strains of autotrophic nitrifiers are present in soil. This was confirmed by Bhuyian and Walker (8), who isolated ammonium oxidizing bacteria from an acid tea soil of Bangladesh having a pH of 5.2.

Alternatively, these soils may contain heterotrophic nitrifiers. Several heterotrophic microorganisms are able to produce $NO_2^-$ and $NO_3^-$ in suitable cultures with organic nitrogenous sources as substrates (9, 10). Weber and Gainey (11) found that considerable nitrate accumulated when four semi-tropical

US soils having pH between 3.9 and 4.9 were subjected to incubation. However, they did not suggest the involvement of a heterotrophic process. Ishaque and Cornfield (12) obtained evidence for heterotrophic nitrification in a Tea soil from Bangladesh (pH 4.2). Chowdhury and Cornfield (13) found a higher amount of nitrate accumulation in an acid red soil of Bangladesh and opined that at least a part of that nitrate might have been produced by heterotrophic nitrification.

The relatively low rate of nitrification in the SA soil despite its favorable pH for nitrification could possibly be due to high salt content of the soil. It is known that salinity affects nitrogen mineralization and nitrification adversely (14).

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