Indian Journal of Hill Frmg 16(1&2) : 38-44 (2003)

MOVEMENT AND DISTRIBUTION OF NITROGEN IN TEA SOILS OF ASSAM

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ABSTRACT

Soil samples from Shantipur and Lattakoojan tea estates of Assam were collected to study the leaching and distribution behaviour of nitrogen in these soils by a column experiment. Results revealed that leaching rate of NH_4-N and NO_3-N was faster in Lattakoojan soil but concentration of NH_4-N and NO_3-N in the leachate was generally higher in Shantipur soil. Leaching of both the forms of nitrogen was maximum when fertilizer was applied whole at a time but splitting of fertilizer showed superiority in reducing N losses due to leaching. Leaching data were fitted to three mathematical equations and it was found out the Elovich equation could effectively describe data on N leaching in these soils.

INTRODUCTION

Nitrogen fertilization in tea crop has become an important issue due to the nature of harvested portion (2-3 leaves and a bud) from the top of the plant, which removes a substantial quantity of nitrogen from soil-plant system. After transformation of applied nitrogen, a part of it is utilized by the crop and soil microbes and a part of it is fixed by soil colloids; while substantial quantity is lost through leaching and volatilization in tea soils. In tea soils of Assam, leaching is one of the most important processes of soil nitrogen. Of the various factors, closely related to the movement of water and degree of N losses, infiltration, percolation rate and water holding capacity which are much related to the soil and amount and time of rainfall are considered as crucial. Therefore, the present work was undertaken to quantify the loss of nitrogen and to develop a mathematical model for predicting N losses in tea soils of Assam.

MATERIALS AND METHODS

Soil samples were collected from two different depths (0-20 cm and 20-50 cm) of each of two tea estates viz., Shantipur and Lattakoojan of Assam representing inceptisols and alfisols, respectively. Soil samples were air dried, mixed well, ground and passed through 2-mm sieve. The basic characteristics of the soils (Table 1) under investigation were analyzed by the standard methods (Jackson, 1973). Available N was determined by alkaline potassium permanganate method as described by Subbaiah and Asija (1956). Available P was extracted by Bray's I extractant and P in the solution was determined by molybdophosphoric blue colour method. Available K was extracted by neutral normal NH4Oac (Jackson, 1973).

A column experiment was carried out to see the leaching and distribution behaviour of N. For this purpose, acrylic tubes (OD = 5 cm, ID = 4.4 cm) of 50 cm length was designed and fabricated to prepare column. Each column was sealed at the lower end with an appropriate size acrylic sheet having a drainage hole in the centre, into which a plastic tube was fitted for collecting leachate from the column. Before packing the soil, the lower end of each column was covered with a disc of filter paper (Whatman No. 42) above which a thin layer of glass wool was placed (Fig. 1). All precautions were taken while designing and fabricating the column for precision of the experiment. Young tea dose (YTD) mixture @ 1000 kg/ ha was added in the column in the form of solution as C1 (control), C2 (at a time), C3 (2-splits), C4 (3-splits) and C5 (4-splits). The leaching study was started 24 hours after the application of YTD mixure so as to allow complete reaction of the mixture with soil. In the experiment, water was ponded at the surface of the column at a constant head of 5 cm by Marriote's arrangement. Approximately, 200 ml water (one pore volume for Shantipur soil) and 130-ml water (one pore volume for Lattakoojan soil) was required to saturate the column. Four volumes of water corresponding to the rainfall amount of the respective tea estates were passed through the column. Each time, 50 and 60 ml of the leachate was collected for Shantipur and Lattakoojan soil, respectively and analyzed for NH_4-N and NO_3-N by the colorometric method as outlined by Onken and Sunderman (1977). Following the percolation of fourth volume of solution, each column was gently tapped to draw the soil column and these were cut at every 3.5 cm distance and the circular sections of 3.5 cm piece was then cut into four equal parts. The sliced samples were air dried, ground and used for extraction and determination of NH_4-N and NO_3-N by colorometric method as outlined by Onken and Sunderman (1977). The following mathematical equations were used to describe leaching data of both the forms of N:

1. Power function equation : $y + a + xb$
2. Semilog equation : $y + a = b \log x$
3. Elovich equation : $y = a = \ln x$

where, y = cumulative N leached (ppm)

x = volume of water percolated through a given depth of soil

a = amount of solution that will be passed from a given depth of soil when leached with unit pore volume of water/solution

b = rate constant

RESULTS AND DISCUSSION

Movement of NH_4-N and NO_3-N : With increase in the quantity of pore volume, both NH_4-N and NO_3-Ndecreased irrespective of the mode of fertilizer application in both Shantipur and Lattakoojan soils. The highest leaching of both the forms was observed with the first pore volume in soils of both the tea estates and thereafter the amount decreased with subsequent addition of water (Table 2,3,,4,5). This behaviour could be attributed to the reaction of added N with less tenacity by the soil components during the initial period. Under this condition, most of the soluble N remained in the soil solution and thus the first pore volume leached out maximum solution N. Susequently, as the amount of N decreased, competition by soil components resulting in lower leaching of the nutrient. The pore volume of the two soils was different. Shantipur soils showed higher pore volume than those of Lattakoojan soil, which might be due to comparatively lighter texure of Shantipur soil. By comparing the treatments, it was found that fertilizer application in a whole at a time showed the highest leaching while the application of fertilizer in 4 splits showed the lowest leaching of both NH_4-N and NO_3-N. The reason for this can be explained as to higher soluble N concentration, when the amount was applied whole at a time. On split application, concentration of N in any form and at any time remained lower, hence subjected to lower leaching with split of the fertilizer. Pratt et al (1960) also found that N movement was more when fertilizer was applied in higher dose at a time. While comparing the soils, it was found that Shantipur soil showed higher concentration of NH_4-N and NO_3-N as compared to Lattakoojan soil irrespective of the treatments which might be due to initial higher available N in the former (Table 1).

The cumulative leaching of NH_4-N and NO_3-N (Table 2,3,4,5) showed that leaching of NH_4-N and NO_3-N gradually increased with each collection of leachate. However, the highest cumulative NH_4-N and

NO_3-N was observed when fertilizer was applied whole at a time, which was closely followed by 2-splits. The lowest cumulative NH_4-N and NO_3-N in both the soils was observed with the control treatment, which was obvious. Next to control, 4-splits of fertilizer application showed the lowest cumulative NH_4-N and NO_3-N in both the soils. The concentration of both NH_4-N and NO_3-N in the leachate and the cumulative concentration of both the forms in both the soils revealed that 4-splits of fertilizer application could appreciably reduce the leaching loss of N by restricting the movement in the soil.

Distribution of NH_4-N and NO_3-N : The distribution of N Increased with increase in each soil slice depth in both the soils of Shantipur and Lattakoojan . This might be due to the fact that in soils of both estates, leaching of applied N took place continuously throughout the soil column and distributed accordingly. Increase in leaching led to bring about more contact of solution N with soil components and as such, available N subsequently became maximum at 31.5-35 cm depth. Beri et al (1978) also observed that N movement was maximum at soil depth of 40 cm. Application of any fertilizer in higher quantities at a time is subjected to more sorption/retention reactions and hence show higher NH_4-N and NO_3-N with application of fertilizer whole at a time. Splitting rationalizes the fertilizer element for higher sorption/ retention reactions.

Mathematical models : Mathematical equations like Power Function, Elovich and Semilog Equation were tested for predicting leaching of NH_4-N and NO_3-N from the two soils on the basis of r2 and standard error (SE) values. While putting leaching data of Shantipur soil in Power Function Equation, it was observed that value of r2 varied from 0.96-0.98 in NH_4-N and 0.94-0.98 in NO_3-N (Table 6) within the treatments and the SE varied from 0.075-0.096 in NH_4-N and 0.055-0.093 in NO_3-N. When the data were fitted into Semilog equation, there were some improvement in the r2 values in both NH_4-N and NO_3-N. Elovich equation, however, showed similar and most significant r2 values (0.99) in all the treatments with the lowest SE values, indicating the efficiency of Elovich equation in describing the leaching of data of Shantipur soil in an efficient way.

In Lattakoojan soil, leaching data when fitted into Power equation showed variation of r2 values in case of NH_4-N and uniform value in case of NO_3-N within the treatment (Table 7). The values of SE were also found to vary. In semi-log equation, there was an improvement of r2 values but SE values increased in all the treatments. While putting these data into Elovich equation, all the treatments showed significantly higher and uniform r2 value (0.99) and the lowest range of SE value. Higher uniform r2 values in all the treatments in both NH_4-N and NO_3-N and the lowest range of SE values as compared to the other equations proved that Elovich equation could predict leaching of N in both the soils of the two tea estates in a better way indicating that this model can be extrapolated for leaching behaviour of N in other soils also.

ACKNOWLEDGEMENT

The paper is a part of the project works funded by National Tea Research Foundation, c/o Tea Board, Kolkata -1 and the authors are grateful to the sponsoring agency for giving financial assistance to the project.

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Table 1. Basic characteristics of Shantipur and Lattakoojan tea estates soils

	Shantipur soils		Lattakoojan soils	
Characteristics	0-20 cm	20-50cm	0-20cm	20-50 cm
Texture	Snady loam	Sandy clay loam	Sandy loam	Sandy clay loam
Sand (%)	52.50	47.54	55.00	52.50
Silt(%)	25.00	27.00	25.00	25.00
Clay (%)	22.50	25.46	20.00	22.50
PH (1:2.5)	4.50	4.70	4.52	4.34
Organic carbon (%)	1.80	1.24	0.58	0.41
CEC (c mol p^+kg/ha^{-1})	8.20	10.50	8.50	9.20
Bulk density (gm/cc)	1.20	1.27	1.40	1.47
Available N (kg/ha)	460.99	354.32	365.20	297.80
Available P (kg/ha)	21.28	18.41	16.80	13.20
Available K (kg/ha)	100.80	71.41	75.80	62.90

Table 2. Concentration of NH4-N in the leachate as affected by mode of fertilizer application in Shantipur soil.

Effluent volume	Collection per pore volume	Control		Whole		2 split		3 split		4 split	
		Conc.	Cumulative mean	Conc.	Cumulative mean	Conc.	Cumulative mean	Conc.	Cumulative mean	Conc.	Cumulative mean
200	1st	0.46	0.46	1.90	1.90	1.60	1.60	1.40	1.40	1.00	1.00
	2nd	0.41	0.87	1.60	3.50	1.30	2.90	1.20	2.60	0.80	1.80
	3rd	0.30	1.17	1.40	4.90	1.10	4.00	1.00	3.60	0.70	2.50
	4th	0.25	1.42	1.28	6.18	1.00	5.00	0.80	4.40	0.60	3.10
400	1st	0.20	1.62	1.12	7.30	0.80	5.80	0.70	5.10	0.50	3.60
	2nd	0.15	1.77	1.00	8.30	0.70	6.50	0.60	5.70	4.40	4.00
	3rd	0.10	1.87	0.80	9.10	0.60	7.10	0.50	6.20	0.31	4.31
	4th	0.90	1.96	0.70	9.80	0.50	7.60	0.40	6.60	3.30	4.61
600	1st	0.09	2.05	0.60	10.40	0.50	8.10	0.32	6.92	0.20	4.81
	2nd	0.08	2.13	0.60	11.00	0.40	8.50	0.30	7.22	0.20	5.01
	3rd	0.08	2.21	0.50	11.50	0.35	8.85	0.21	7.43	0.18	5.19
	4th	0.07	2.28	0.50	12.00	0.30	9.15	0.20	7.63	0.18	5.37
800	1st	0.06	2.34	0.42	12.42	0.30	9.45	0.20	7.83	0.10	5.47
	2nd	0.06	2.40	0.40	12.82	0.28	9.73	0.18	8.01	0.10	5.57
	3rd	0.06	2.46	0.40	13.22	0.28	10.01	0.18	8.19	0.10	5.67
	4th	0.06	2.52	0.38	13.60	0.28	10.29	0.18	8.37	0.10	5.77

CM: Cumulative mean

Table 3. Concentration of NO_3-N in the leach ate as affected by mode of fertilizer application in Shantipur Soil.

Effluent volume	Collection per pore volume	Control Conc.	Cumulative mean	Whole Conc.	Cumulative mean	2 split Conc.	Cumulative mean	3 split Conc.	Cumulative mean	4 split Conc.	Cumulative mean
200	1st	2.00	2.00	6.50	6.50	5.50	5.50	4.50	4.50	3.50	3.50
	2nd	1.50	3.50	6.00	12.50	4.50	10.00	3.50	8.00	2.60	6.10
	3rd	1.40	4.90	5.00	17.50	3.50	13.50	2.50	10.50	2.00	8.10
	4th	1.10	6.00	4.10	21.60	3.00	16.50	2.30	12.80	1.50	9.60
400	1st	1.00	7.00	3.50	25.10	2.50	19.00	2.30	15.10	1.30	10.30
	2nd	0.90	7.90	3.00	28.10	2.00	21.00	1.70	16.80	1.00	11.90
	3rd	0.80	8.70	2.50	30.60	1.70	22.70	1.50	18.30	0.80	12.70
	4th	0.60	9.30	2.30	32.90	1.50	24.20	1.40	19.70	.60	13.30
600	1st	0.50	9.80	2.00	34.90	1.30	25.50	1.30	21.00	0.50	13.80
	2nd	0.50	10.30	1.80	36.70	1.20	26.70	1.00	22.00	0.40	14.60
	4th	0.50	11.30	1.60	40.10	1.00	28.70	1.00	24.00	0.40	15.00
800	1st	0.50	11.80	1.50	41.60	0.90	29.60	0.90	24.90	0.20	15.20
	2nd	0.50	12.30	1.50	43.10	0.80	30.40	0.90	25.80	0.20	15.40
	3rd	0.50	12.80	1.40	44.50	0.80	31.20	0.80	26.60	0.20	15.60
	4th	0.50	13.30	1.40	45.90	0.80	32.00	0.80	27.40	0.20	15.80

Table 4 : Concentration of NH_4^+ N in the leach ate as affected by mod of fertilizer application in Lattakoojan soil

Effluent volume	Collection per pore volume	Control Conc.	Cumulative mean	Whole Conc.	Cumulative mean	2 split Conc.	Cumulative mean	3 split Conc.	Cumulative mean	4 split Conc.	Cumulative mean
130	1st	0.45	0.45	1.10	1.10	0.90	0.90	0.80	0.80	0.60	0.60
	2nd	0.30	0.75	0.90	2.00	0.60	1.50	0.50	1.30	0.40	1.00
260	1st	0.20	0.95	0.70	2.70	0.50	2.00	0.40	1.70	0.30	1.30
	2nd	0.15	1.10	0.60	3.30	0.40	2.40	0.30	2.00	0.20	1.50
390	1st	0.10	1.20	0.50	3.80	0.32	2.72	0.20	2.20	0.10	1.60
	2nd	0.08	1.28	0.40	4.20	0.30	3.02	0.20	2.40	0.10	1.70
520	1st	0.05	1.33	0.30	4.50	0.25	3.27	0.10	2.50	0.08	1.78
	2nd	0.05	1.38	0.30	4.80	0.20	3.47	0.10	2.60	0.80	1.86

Table 5. Concentration of NO_3 -N in the leachate as affected by mode of fertilizer application in Lattakoojan soil

Effluent volume	Collection per pore volume	Control Conc.	Control Cumulative mean	Whole Conc.	Whole Cumulative mean	2 split Conc.	2 split Cumulative mean	3 split Conc.	3 split Cumulative mean	4 split Conc.	4 split Cumulative mean
130	1st	2.50	2.50	5.50	5.50	5.00	5.00	4.50	4.50	3.50	3.50
	2nd	2.00	4.50	5.00	10.50	3.50	8.50	3.00	7.50	2.00	5.50
260	1st	1.20	5.70	4.00	14.50	2.50	1.00	2.00	9.50	1.50	7.00
	2nd	1.00	6.70	2.60	17.10	2.20	13.20	1.50	11.0	1.00	8.00
390	1st	0.70	7.40	2.40	19.50	2.00	15.20	1.30	12.30	0.80	8.80
	2nd	0.60	8.00	2.20	21.70	1.50	16.70	1.00	13.30	0.80	9.60
520	1st	0.50	8.50	2.00	23.70	1.50	18.20	0.90	14.20	0.50	10.10
	2nd	0.50	9.00	2.00	25.70	1.30	19.50	0.90	15.10	0.50	10.60

Table 6 : Correlation coefficient (r^2) and standard Error (SE) of estimate of Mathematical models used for predicting leaching of NH_4-N and NO_3-N in Shantipur soil.

Treatment	Power Function (Y = a × b)		Semilog (Y = a + b log x)		Power Function (Y = a + b In t)	
	r^2	SE	r^2	SE	r^2	SE
ND_4-N						
Control	0.96	0.096	0.98	00.029	0.99	0.0001
Whole	0.98	0.077	0.98	0.522	0.99	0.2500
2 splits	0.98	0.075	0.96	0.322	0.99	0.0190
3 splits	0.96	0.094	0.98	0.180	0.99	0.0006
4 splits	0.96	0.094	0.98	0.128	0.99	0.0001
NO_3-N						
Control	0.98	0.058	0.98	0.546	0.99	0.0001
Whole	0.98	0.078	0.98	1.560	0.99	0.1760
2 splits	0.98	0..077	0.98	0.756	0.99	0.0280
3 splits	0.98	0.055	0.98	1.025	0.99	0.0006
4 splits	0.94	0.093	0.98	0.0277	0.99	0.0007

Table 7. Correlation coefficient (r^2) and standard Error (SE) of estimate of Mathematical models used for predicting leaching of NH_4-N in Lattakoojan soil.

Treatment	Power Function (Y = a × b)		Semilog (Y = a + b log x)		Power Function (Y = a + b In t)	
	r^2	SE	r^2	SE	r^2	SE
ND_4-N						
Control	0.96	0.069	0.98	0.015	0.99	0.0001
Whole	0.98	0.055	0.98	0.152	0.99	0.0057
2 splits	0.98	0.003	0.96	0.117	0.99	0.0033
3 splits	0.98	0.057	0.98	0.042	0.99	0.0018
4 splits	0.96	0.057	0.98	0.026	0.99	0.0007
NO_3-N						
Control	0.98	0.069	0.99	0.86	0.99	0.039
Whole	0.98	0.0638	0.99	0.835	0.99	0.051
2 splits	0.98	0.035	0.98	0.702	0.99	0.063
3splits048	0.98	0.048	0.98	0.259	0.99	0.044
4splits	0.98	0.044	0.98	0.146	0.99	0.001

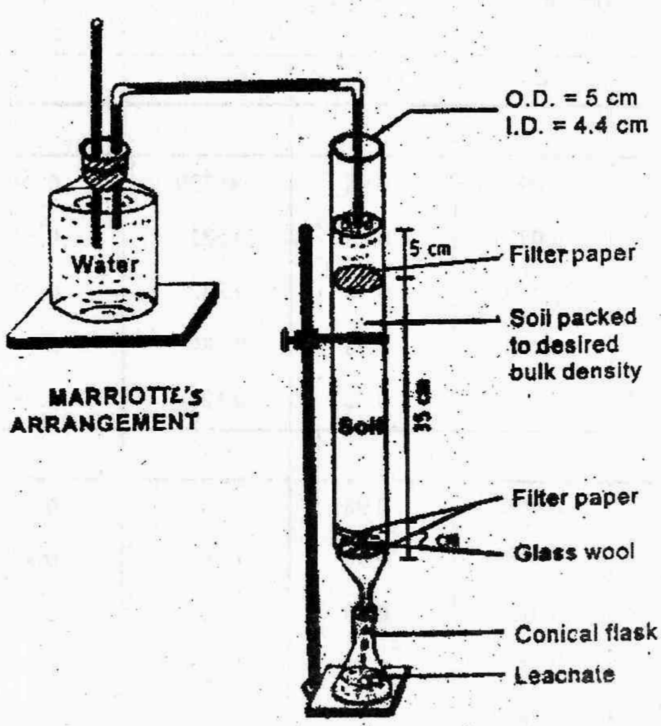

Fig. 1. Schematic Diagram of Laboaratory Coloumn Experiment