

## THE VOLATILISATION LOSSES OF NITROGEN FROM ADDED UREA IN SOME SOILS OF BANGLADESH

by G. H. RASHID

Laboratoire d'Ecologie végétale, 431  
Université de Paris-Sud, Centre d'Orsay, 91405 Orsay, France

### SUMMARY

Considerable volatilisation loss of nitrogen from added urea was recorded in the Coastal saline and Madhupur red soils of Bangladesh under laboratory conditions. The loss was highly magnified by the presence of decomposable organic materials having high C/N ratios.

### INTRODUCTION

The volatilisation losses of nitrogen from urea added to soils have been considered to be related to the presence of lime and high pH<sup>1 4 6 8 10 14</sup>; high soil temperature<sup>5 6</sup>; low exchange capacity<sup>1 6</sup>; loss of moisture from soil<sup>4 6</sup>; or high moisture status leading to water-logging<sup>11 15</sup>. Very limited informations are available on the gaseous loss of nitrogen from urea in presence of added decomposable organic materials in soils. Meyer *et al.*<sup>10</sup> and Anderson<sup>1</sup> observed considerable losses due to volatilisation when urea was applied to soil covered with plant residues. Khan and Rashid<sup>9</sup> reported that the volatilisation loss of nitrogen from added urea was markedly accelerated by the presence of decomposable organic materials having high C/N ratios.

In Bangladesh urea synthesised from natural gas, is the only indigenous and cheap N-carrier which is being used in ever increasing rates in the recent years. The gaseous loss of nitrogen from added urea makes the situation quite alarming as it affects adversely the economy of the farmers. In sub-tropical and tropical humid

environments the application of decomposable organic materials, with a high C/N ratio, such as cow-dung, composts, *etc.*, followed by the addition of nitrogenous fertilizer-urea, creates a condition where the transformation of the applied N-carrier is likely to be greatly accelerated. Therefore, work has been undertaken to examine the effect of various kinds of organic materials on the fate of added urea using two different soils of Bangladesh under laboratory conditions.

#### MATERIALS AND METHODS

##### *Soils*

Two soils, the Coastal saline and Madhupur red soils, were collected from Barguna in Patuakhali and Madhupur forest area in Mymensingh districts respectively, from a depth of 0–12". The mechanical and some chemical composition of the soils are reported in Table 1.

TABLE 1  
Mechanical and chemical composition of the soils

Constituents	Soils	
	Coastal saline	Madhupur red
<i>Mechanical (air-dry basis)</i>		
Sand (%)	57.3	49.32
Silt (%)	26.8	21.52
Clay (%)	15.6	29.13
Moisture (105° C) (%)	0.86	1.32
<i>Chemical (oven-dry basis)</i>		
pH	8.2	5.5
Organic C (%)	0.54	0.51
NH <sub>4</sub> -N (mg %)	0.52	1.50
NO <sub>3</sub> -N (mg %)	1.30	0.56
Total N (%)	0.03	0.05
C/N ratio	13.50	10.20
Truog's P (mg %)	1.72	2.51
1% Citric acid soluble K (mg %)	3.61	5.98
Total P (%)	0.03	0.04
Total K (%)	0.41	0.50
Total Ca (%)	1.59	0.50

##### *Organic materials*

Three different kinds of organic materials were used: cow-dung, molasses and water-hyacinth compost. Bonemeal, containing appreciable amount of organic carbon (Table 2) was also used. Cow-dung and water-hyacinth were allowed to undergo decomposition for a period of two months under laboratory conditions. The decomposed materials were then oven-dried at 70°C.

Data on initial total N, organic carbon (on oven-dry basis) and C/N ratios of the organic materials are presented in Table 2. Cow-dung and water-hyacinth compost with C/N ratios of 28 and 20 respectively and molasses containing 48.3 per cent organic C and a trace of N were applied at the rate of 500 lbs organic carbon per acre. Bonemeal with C/N ratio of 4, and 9 per cent of phosphorus was applied at the rate of 60 lbs P per acre.

TABLE 2  
Composition of organic materials used in the experiment

Organic materials	Basis of application	% total N	% C	C/N ratio	% P
Cow-dung	500 lbs organic C/acre	1.18	33.36	28.23	—
Molasses	„	Trace	48.30	—	—
Water-hyacinth compost	„	1.05	29.80	19.80	—
Bonemeal	60 lbs P/acre	2.11	7.80	3.69	9.05

#### *Procedure*

200 g air-dry soil was placed in petri-dishes. Organic materials were spread uniformly on the soil taken in the petri-dishes and incorporated into the soil to a depth of about 2–4 mm. The moisture content was maintained at 40 per cent level. The mixture of soil and organic materials were allowed to undergo biochemical, chemical and physico-chemical reactions for seven days. Moisture content was then maintained at 35 per cent throughout the experimental period, adjusting every 24 hours. Ten days after the start of the experiment, urea (C.P.) equivalent to 240 lbs N per acre was applied uniformly on the surfaces of the organic matter treated soils in petri-dishes. There were ten different treatments in each soil, as follows:

1. Soil (control); 2. Soil + cow-dung; 3. Soil + cow-dung + urea;
4. Soil + molasses; 5. Soil + molasses + urea; 6. Soil + water-hyacinth compost;
7. Soil + water-hyacinth compost + urea; 8. Soil + bonemeal;
9. Soil + bonemeal + urea and 10. Soil + urea.

Three series of experiments were set up with each soil, two replicates per treatment, at room temperature. Samples were withdrawn for the determination of total N and moisture at three different time intervals, *viz* 24, 72 and 168 hours after the application of urea.

#### *Analytical*

Total N content of soils was determined following Kjeldahl's method modified by Jackson<sup>7</sup>. This determination also included nitrate-N. Total N of organic materials was determined by the A.O.A.C. method<sup>2</sup>. Ammoniacal nitrogen was determined by Richardson's modification of Olsens's method as

described by Piper<sup>12</sup>.  $\text{NH}_4\text{-N}$  was distilled over by  $\text{MgO}$ ; and nitrate nitrogen was determined on the same distillate using Devarda's alloy<sup>12</sup>.

Mechanical composition of the soils was analysed by Pipette Sampling, as described by Piper<sup>12</sup>, and organic carbon by the Wet Oxidation method of Walkley and Black<sup>16</sup>. Soil pH was measured with a glass electrode. Soluble potassium in the soil was extracted by Dyer's 1.0 per cent citric acid solution, K in this extract was estimated by precipitation with cobalti nitrite and oxidation with  $\text{KMnO}_4$  as outlined by Piper. Available phosphorus in the soil was extracted with 0.002 N  $\text{H}_2\text{SO}_4$ <sup>13</sup> and then estimated colorimetrically by measuring the density of blue colour of the phosphomolybdate complex<sup>7</sup>. Total phosphorus, total potassium and total calcium were determined from a hydrochloric acid extract of a sodium carbonate fusate. Total phosphorus and potassium were determined in the extracts by adopting the methods described above and total calcium by Piper's method<sup>12</sup>. Total phosphorus of bonemeal was estimated colorimetrically in the extracts prepared by the A.O.A.C. method<sup>2</sup>.

#### RESULTS AND DISCUSSION

The losses of nitrogen due to volatilisation of the added urea (Figures 1 and 2) were calculated on the basis of net depletion at specific time intervals. This was estimated by deducting the total amount of nitrogen present in the soil after the specified time period from the sum total of initial N (Soil N + added N).

Values of the gaseous loss of N from added urea are presented in Figures 1 and 2. Results show an appreciable amount of loss of urea N after 24 hours from the time of the setting up of the experiment. 34 and 27 percent loss of N were recorded in the Coastal saline and Madhupur red soils respectively. Such N loss from soils where only urea was incorporated increased with time *i.e.* upto 168 hours (Figures 1 and 2). Similar loss of nitrogen from urea added to the Brahmaputra and Gangetic alluviums was reported by Khan and Hoque<sup>8</sup> and Khan and Rashid<sup>9</sup>.

It is observed that the addition of organic materials, except bonemeal, caused a significant increase in the N loss from added urea under both the soil conditions (*viz* Coastal and Madhupur soils). Bonemeal application did not cause any change in the loss of the urea-N upto 72 hours in the Coastal saline soil. But there was a slight increase in the N loss after 168 hours from the time of the urea treatment. Bonemeal application accounted for some increase in the urea-N loss in the Madhupur red soil which was, however, not

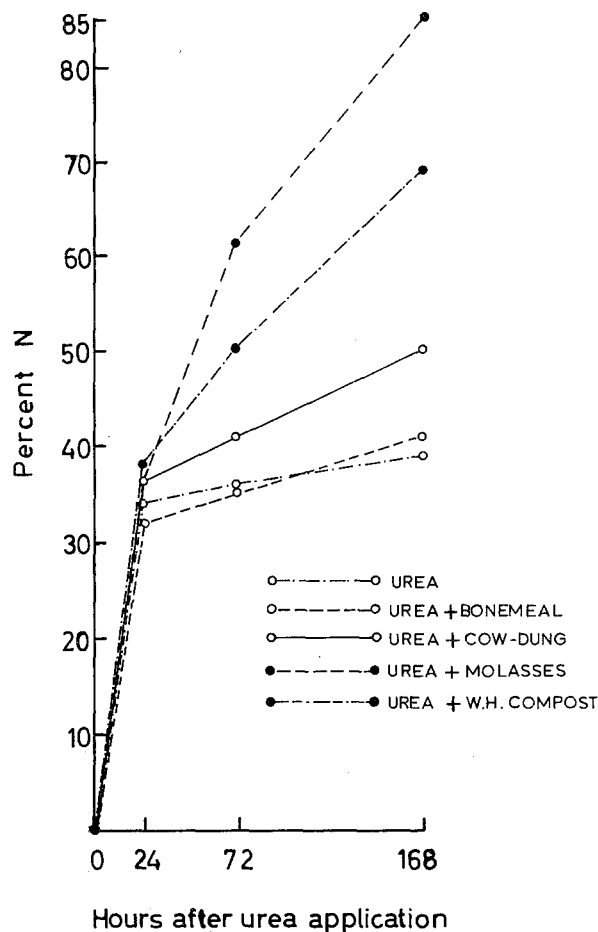


Fig. 1. Loss of nitrogen from added urea in coastal saline soil (%).

appreciable throughout 168 hours experimental period. In the present experiment the incorporation of molasses caused a maximum loss of N (85 per cent) from the added urea in the Coastal saline soil. Water-hyacinth compost and molasses accounted for maximum N-loss from the added urea (74–75 per cent of the added N) in the Madhupur red soil. Similar N loss from the added urea in presence of decomposable organic materials (such as cow-dung, molasses and water-hyacinth compost) was found to occur also in the Brahmaputra and Gangetic alluvial soils of Bangladesh<sup>9</sup>.

The high percentage loss (75–85) of nitrogen from added urea may

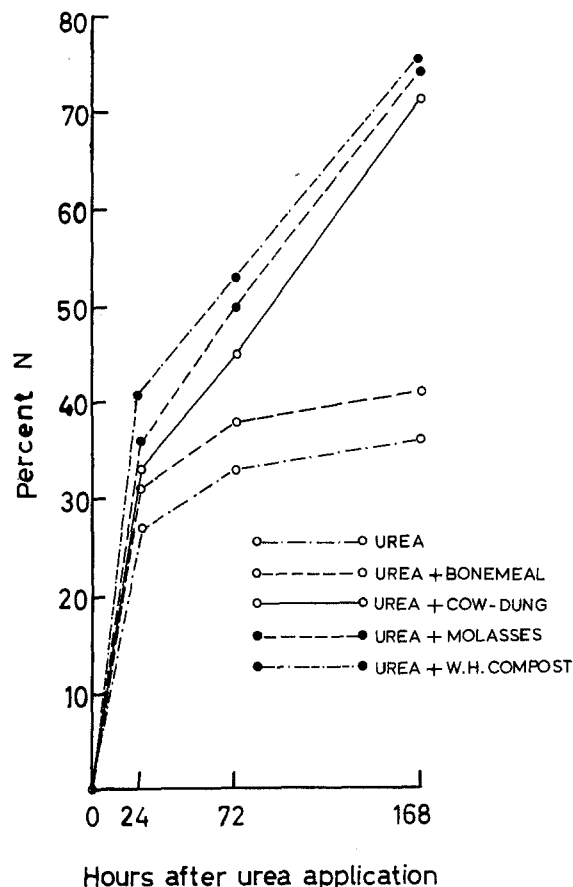


Fig. 2. Loss of nitrogen from added urea in Madhupur red soil (%).

be due to an increased rate of ammonification and decreased nitrification. This fact may be explained by considering that the decomposable organic materials, like cow-dung, molasses and waterhyacinth compost with high C/N ratios readily supplied energy to general purpose heterotrophic soil organisms which are primarily concerned with amination and ammonification and under these conditions the nitrifying organisms remain more or less inactive<sup>3</sup>. Khan and Rashid<sup>9</sup> in an earlier work under similar conditions with different soils reported that the organic materials having high C/N ratios cause a significant gaseous loss of nitrogen from added urea due to an enhanced rate of ammonification and decreased nitrifi-

fication.  $\text{NH}_4\text{-N}$  and  $\text{NO}_3\text{-N}$  were not determined in this experiment because the values of total N were considered to indicate the fate of added N, although their values would have shown a detailed picture of urea-N. It may, therefore, be assumed that in the absence of quick nitrification the ammonia produced from the hydrolysis of urea might have escaped through volatilisation due to high pH in the soil (Table 3).

TABLE 3

Soil pH in the Coastal saline and Madhupur red soils at different times (hours) after urea and organic materials treatments

Treatments	pH of the soils					
	Coastal saline			Madhupur red		
	24	72	168	24	72	168
Soil (control)	8.2	8.2	8.2	5.7	5.7	5.7
Soil + urea	9.0	9.3	9.4	7.0	7.2	7.1
Soil + cow-dung	8.1	8.1	8.3	5.6	5.7	5.7
Soil + cow-dung + urea	9.2	9.5	9.4	7.1	7.2	7.3
Soil + molasses	8.3	8.2	8.1	5.6	5.7	5.7
Soil + molasses + urea	9.4	9.4	9.0	7.0	7.3	7.4
Soil + water-hyacinth compost	8.1	8.2	8.1	5.7	5.6	5.7
Soil + water-hyacinth compost + urea	9.2	9.5	9.2	7.1	7.2	7.4
Soil + bonemeal	8.2	8.2	8.2	5.7	5.6	5.6
Soil + bonemeal + urea	9.0	9.3	9.4	7.0	7.1	7.1

This experiment was conducted in the summer months of May and June with an average temperature of  $31^\circ\text{C}$ . This high temperature caused a considerable loss of moisture through evaporation. Such loss of moisture due to evaporation might have further accelerated the loss of gaseous nitrogen (produced from the added urea) from the seat of soil reaction<sup>5 6</sup>. The present work reveals that from the economic point of view one should be careful in applying decomposable organic materials with a high C/N ratio before the application of urea in the sub-tropical and tropical humid soils.

Received 22 March 1976

## REFERENCES

- 1 Anderson, J. R., Urease activity, ammonia volatilisation and related microbiological aspects in some South African soils. Proc. 36th Congr. S. Afr. Sug. Tech. ASS. 97-105 (1962).

- 2 A.O.A.C., Methods of Analysis. New York: Assoc. Official Agr. Chem. (1960).
- 3 Buckman, H. O. and Brady, N. C., The Nature and Properties of Soils, New York, Macmillan (1964).
- 4 Ernst, J. W. and Massey, H. F., The effect of several factors on volatilisation of ammonia formed from urea in the soil. Soil Sci. Soc. Am. Proc. **24**, 87-90 (1960).
- 5 Gasser, J. K. R., Urea as a Fertilizer. Soils Fert. **27**, 175-180 (1964).
- 6 Harding, R. B., Embleton, T. W. and Jones, W. W., Leaching and gaseous losses of nitrogen from some non-tilled California soils. California Citrograph. July (1963).
- 7 Jackson, M. L., Soil and Plant Analysis. Constable and Co. Ltd. London (1962).
- 8 Khan, D. H. and Hoque, M. Z., Volatilisation loss of nitrogen from urea added to some soils of East Pakistan. J. Sci. Food Agric. **16**, 725-729 (1965).
- 9 Khan, D. H. and Rashid, G. H., Losses of nitrogen from urea in some soils of East Pak. Exp. Agric. **7**, 107-112 (1971).
- 10 Meyer, R. D., Olson, R. A. and Rhoades, H. E., Ammonia losses from fertilized Nebraska soil. Agron. J. **53**, 241-244 (1961).
- 11 Okuda, A., Takahashi, E. and Yoshida, M., The volatilization of ammonia transformed from urea applied under upland and water-logged conditions. J. Sci. Soil, Tokyo **31**, 273-278 (1960).
- 12 Piper, C. S., Soil and Plant Analysis. Adelaide University Press (1950).
- 13 Truog, E., The determination of readily available phosphorus of soils. J. Am.Soc. Agron. **29**, 874-882 (1930).
- 14 Volk, G. M., Volatile loss of ammonia following surface application of urea. Agron. J. **51**, 746-749 (1959).
- 15 Wahhab, A., Mahmud, K. and Ishaq, M., Nitrification of urea and its loss through volatilization of ammonia under different soil conditions. J. Agric. Sci. **55**, 47-51 (1959).
- 16 Walkley, A. and Black, I. A., An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci. **37**, 29-38 (1934).