

Transformations of Surface-applied Urea in Three Soils of Varying pH

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Relatively little information is available on the characterization of the rates of urea hydrolysis and nitrification in the field, but these data are critical for developing fertilizer application strategies (Burford & Sahrawat 1989). This study aimed to obtain information on the transformation of surface-applied urea in three soils with varying pH. The transformation of urea investigated included its hydrolysis, the volatile loss of ammonia and the nitrification of ammonium produced with a range in natural pH under optimal conditions of soil moisture and temperature.

The soils used were surface (0-15 cm) samples of a Vertisol and two Alfisols (Alfisol 1 and Alfisol 2) at ICRISAT (International Crops Research Institute for the Semi-Arid Tropics Center). The Vertisol belongs to the Kasireddipalle series and the two Alfisols belong to the Patancheru series. The soil samples were air-dried, ground and sieved through a 2-mm screen. The Vertisol is a calcareous clay, had a pH (1:2 water) of 8.35, an organic C content of 0.45 per cent, total N content of 490 mg kg⁻¹ and water content at 33 kPa was 38 g kg⁻¹. The Alfisol 1, a sandy loam had a pH of 6.20, an organic C content of 0.42 per cent, total N content of 512 mg kg⁻¹ and water content at 33 kPa was 16 g kg⁻¹. Alfisol 2, a sand had a pH

of 4.50, organic C content of 0.39 per cent, total N content of 358 mg kg⁻¹ and water content at 33 kPa was 80 g kg⁻¹. The soil samples were air-dried, ground and sieved through a 2 mm screen. Soil analysis was done as described earlier (Sahrawat 1984).

Soil samples (10g) in duplicate were transferred to 125 mL bottles. The soil samples were treated with an aqueous solution of urea so as to add 100 mg N kg⁻¹ soil to the soil surface. Water was then added to bring the soil water potential to 33 kPa. A 10 mL glass beaker containing 5 mL of 0.5 M H₂SO₄ was put in each flask to absorb the volatilized ammonia from the samples. The size of the beaker was such that the top of the beaker exactly fitted in the mouth of the bottle. Thus the beaker was held from the top of the bottle and did not obstruct the release of ammonia. The bottles were capped gently and incubated at 30°C. The water content of the soil samples was maintained by periodic compensation for evaporative loss. For each soil, there were controls without any urea amendment.

The beakers, to absorb ammonia, were removed at each soil sampling and the ammonia absorbed was determined by distilling the contents of the beakers with 5M NaOH solution (Keeney & Nelson 1982).

The soil samples were analyzed for urea-N, NH₄-N, NO₂-N and NO₃-N at 1,2, 3, 7 and 10

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days of incubation by extracting the samples with 2M KCl containing phenyl mercuric acetate (Mulvaney & Bremner 1979). Urea in the extract was determined by a modified diacetyl monoxime colorimetric method (Mulvaney & Bremner 1979). The NH₄ and NO₃-N contents of the extracts were determined by steam distillation methods and NO₂-N content by modified Griess-Ilosvay method (Keeney & Nelson 1982).

The recovery of urea-N at day 10 was quantitative and NO₂-N content of the samples never exceeded 0.1 mg N kg⁻¹ soil. The net changes (treatment value - control value) in the content of urea, NH₃-, NH₄- and NO₃-N (Table 1) indicated that the hydrolysis of urea was complete in one day in the Vertisol (pH 8.35), by two days in the Alfisol 1 (pH 6.20), but the hydrolysis was not complete by 10th day in the Alfisol 2 (pH 4.50). These results agree with reports that the rates of urea hydrolysis are slow in soils with acidic pH and the rates are usually high in soils

with neutral or higher pH (Bremner & Mulvaney 1978; Goswami & Sahrawat 1982).

The hydrolysis of urea to ammonia creates alkalinity and this could lead to the gaseous loss of ammonia. The volatile loss of ammonia was greatest in the Vertisol (14% of the added urea-N), followed by Alfisol 1 (6% of the added urea-N) as ammonia and Alfisol 2 recorded the least loss as ammonia (2% of the added urea-N). The pattern of ammonia loss was similar in the three soils and most of the ammonia loss had occurred in two days. The ammonia loss from the Vertisol and Alfisol 1 peaked a day after urea hydrolysis was complete. This criterion provides a rough guide to the duration of the occurrence of ammonia volatilization loss from soils following urea application especially when the soil water content and temperature are in the optimal range (Sahrawat 1984).

The nitrification of the ammonium produced varied greatly in the three soils. While

Table 1. Transformation of urea-N in the three soils

Incubation period(days)	Added urea - N recovered as			
	Urea-N	NH ₃ -N	NH ₄ -N	NO ₃ -N
	mg N kg ⁻¹ soil			
<i>Vertisol</i>				
1	0	6	82	5
2	0	14	73	7
3	0	14	65	15
7	0	14	7	72
10	0	14	4	78
SE±	0.0	1.6	16.8	16.3
<i>Alfisol 1</i>				
1	8	3	81	3
2	0	5	93	3
3	0	6	90	4
7	0	6	60	34
10	0	6	30-	64
SE±	1.6	0.6	11.7	12.1
<i>Alfisol 2</i>				
1	96	1	2	0
2	93	1	4	1
3	86	2	9	1
7	58	2	37	1
10	22	2	74	1
SE±	13.9	0.2	13.7	0.2

78 per cent of the applied urea-N was nitrified in the Vertisol and 64 per cent in Alfisol 1, only one per cent of the urea-N was nitrified in Alfisol 2 in 10 days of incubation (Table 1). Sahrawat (1982) found that two acid sulphate soils (pH 3.4 and 3.7) and an acid soil (pH 4.4) did not nitrify at all during four weeks. Mineral and organic soils, having pH greater than 6.0, nitrified the soil ammonium at rapid rates. Nitrification in these soils as measured by $\text{NO}_3\text{-N}$ accumulation, was significantly correlated with soil pH ($r = 0.86$, $n = 10$).

The results of the present study agree with others (Focht & Verstraete 1977; Sahrawat 1982) indicating that nitrification takes place at a low rate in soils having a pH lower than 5.0 and that an acid soil is a deterrent to nitrification. Nitrification in the three soils varied greatly. While the highest rate of nitrification in the Vertisol, of $10.3 \text{ mg NO}_3\text{-N kg}^{-1} \text{ soil day}^{-1}$ was attained between third and seventh day, it was attained between seventh day and tenth day in the case of Alfisol 1 when the nitrification rate became $6.4 \text{ mg NO}_3\text{-N kg}^{-1} \text{ soil day}^{-1}$. However, more close soil sampling period (every day) would have provided more precise data on the rates of nitrification in these soils. The Alfisol 2 had an extremely slow rate of nitrate production throughout the 10 days of study.

The practical implications of the results of the study are that the volatile loss of ammonia would be significant from the Vertisol and the

Alfisol with near neutral pH, following urea application on to the surface of a moist soil. The leaching of urea could be a serious problem in the acidic sandy Alfisol if heavy rainfall occurs soon after application of urea because of the very slow rate of urea hydrolysis in the soil. The retardation of urea hydrolysis in such soils would further accentuate the loss of urea by leaching (Sahrawat 1980).

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