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EFFECT OF DIFFERENT FACTORS ON AMMONIA VOLATILIZATION FROM UREA IN ALLUVIAL SOILS

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Under laboratory conditions, the effect of clay content, plant cover, plant species, seasonal temperature and the size of urea granules on ammonia loss was investigated. Increasing clay content from 15.6 to 31.6% reduced the ammonia loss by 50%. The loss of ammonia from cropped soil was 2.4 times more than that from the bare soil. The average loss of ammonia in soil under Jantar (legume), wheat, eucalyptus (tree), grass, sugarcane and garden was 19.4, 18.6, 18.6, 13.4, 7.6 and 6.9% N, respectively. The loss of ammonia from soil samples collected in February was 30% lower than that of samples collected in June. The size of urea granules was found to be directly correlated to ammonia loss.

INTRODUCTION

Presently urea is the major source of nitrogen used for crop production in Pakistan. But it is inferior to other nitrogen fertilizers (Gasser, 1964). Recent research (Vlek and Craswell, 1981) showed that this low efficiency is due to ammonia volatilization from urea. As the risk of ammonia volatilization is very high in alkaline soils, there is a need of developing methods for the control of ammonia loss of nitrogen from urea.

Changes in the physical environment of the soil influence ammonia volatilization from urea; increasing the bulk density markedly increased hydrolysis of urea (Savant *et al.*, 1987), mulching soil with corn leaves decreased ammonia volatilization (Clay *et al.*, 1990).

The control of ammoniacal loss of nitrogen warrants the study regarding the contribution of various soil parameters and factors in such loss. Thus the objective of this study was to investigate the effect of soil series, plant cover, clay content, seasonal temperature and physical condition of urea on ammonia loss from the alluvial alkaline soil.

MATERIALS AND METHODS

In order to study the effect of different soil parameters and factors on ammoniacal loss of nitrogen from urea applied to soil, following laboratory experiments were done.

Experiment I: Effect of clay content on ammonia volatilization from urea: Two soil samples having 15.6 and 31.6% clay were collected from surface 0-15 cm layer. Wheat crop was growing in both the fields at the time of soil sampling.

Experiment II: Effect of plant cover on ammonia volatilization: Soil samples from surface 0-15 cm layer from two adjacent fields (one cropped and one bare) were collected. For studying the effect of plant species on ammonia loss soil profile samples in 15 cm depth increments were collected from fields under Jantar (legume), wheat, grass, eucalyptus (tree), sugarcane and garden.

Experiment III: Effect of seasonal temperature on ammonia volatilization: For studying the effect of seasonal temperature on ammonia loss soil samples were collected in February, April, May and June.

Experiment IV: Effect of sizes of urea granules on ammonia volatilization: Three sizes of granules were selected, i.e. 0, 2.2 and 17.8 mm diameter. Nitrogen applied to soil was equivalent to the largest granule in the three sizes of urea granules.

The soil samples collected from the fields were air dried under shade. The air dried samples of soils (500 g) were placed in 1 l Erlenmeyer flasks. The amount of urea N applied was equivalent to 120 kg/ha (on area basis). The water content in the soil was maintained at 20% (W/V). The measurements were made at room temperature (24 °C ± 2 °C). As soon as the urea N was added to the soil, compressed air scrubbed through 0.5N H_2SO_4 and then through water was passed into the reaction flasks. The air left the flasks through the glass tubing and passed into the 4% boric acid solution containing bromocresol green and methyl red indicators (Matocha, 1976). Capillary tubes were used at this point to equalize the pressure in the system. The ammonia evolved in the reaction flasks was absorbed in the boric acid solution which was determined by titrating against standard H_2SO_4.

RESULTS AND DISCUSSION

The measurement of ammoniacal loss of N from urea applied to two soils having 15.6% and 31.6% clay showed that higher clay content would reduce the ammonia loss of N (Table 1). In a period of 40 days the loss of N observed in coarse soil and fine soil was 42.5 and 19.5%, respectively. These results indicated that urea fertilizer is not a suitable fertilizer for coarse textured soils. The loss of ammonia from urea follows its hydrolysis by urease enzyme and its activity is assessed as mg NH_4-N released/100 g soil/hour. In general, the fine textured soils have the higher mean urease activities. There is trend for the heavier textured soils to also contain higher levels of organic carbon which itself is positively related to urease activity. Colloids both organic and inorganic apparently act as stabilizing agents for urease released into the soil (Pinck and Allison, 1961), so that where levels of colloids are low, sites for accumulation and preservation of extracellular urease may be restricted. Higher contents of colloids, however, may provide a potentially large number of sites for preservation of urease activity. The results presented here appear to contradict these statements. In fact, it is not the contradiction but an evidence showing that colloidal materials (clay and organic matter) also provide sites for adsorption of NH_4 ions and thus reduce the potential of ammonia for volatilization. Thus soil with higher clay content exhibited lower ammoniacal loss of nitrogen.

Table 1. Effect of clay content on ammonia volatilization (% N) from urea

Days	% clay		L.S.D.
	15.6	31.6	(P = 0.05)
10	21.5	6.5	7.8
20	32.5	12.5	9.5
30	37.5	16.5	10.2
40	42.5	19.5	13.3

The comparison of ammonia loss in soil samples collected from cropped and bare field, (Table 2) showed that the soil supporting plants had more activity which was conducive to ammonia loss of nitrogen from urea. The loss of ammonia recorded in

40 days was 32.5 and 12.5% in cropped and bare soils, respectively.

Table 2. Effect of plant cover on ammonia volatilization (% N) from urea

Days	Bare soil	Cropped soil	L.S.D. (P = 0.05)
10	3.5	7.0	3.0
20	6.0	14.0	7.2
30	9.0	22.0	9.6
40	12.5	32.5	14.0

The surface 0-15 cm layer of soil under Jantar (legume) and tree (eucalyptus) had the highest urease activity which resulted in higher loss (Fig. 1). In case of wheat and grass, 15-30 cm layer had the highest activity and accordingly higher loss of ammonia was recorded in these samples.

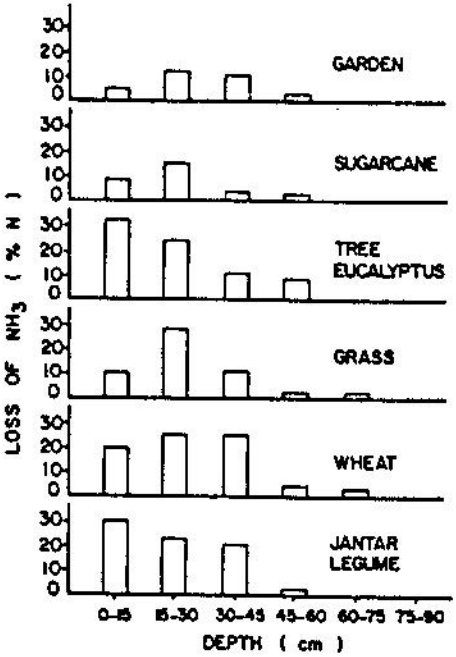

Fig. 1. Effect of crop and depth of soil on loss of ammonia from urea.

The measurement of ammonia loss in soil samples from different depths also showed that urease enzyme was present in the surface 45 cm layer of soil. No measurable loss of ammonia occurred in soil collected from profiles at depth beyond 60 cm. Average loss of ammonia in 14 days observed in 0-60 cm profile samples from fields under Jantar (legume), wheat, eucalyptus, grass, sugarcane and garden was 19.4, 18.6, 18.6, 13.4, 7.6 and 6.9% N, respectively. These variations may also be due to fluctuations in the urease activities with plant species (McGarity and Myers, 1967).

The highest loss of N was recorded in samples collected in June and being the lowest in samples collected in February (Table 3). The loss of ammonia from soil samples taken in February was 30% lower than that observed in samples collected in June. This indicated that urease activity fluctuated with the season (McGarity and Myers, 1967).

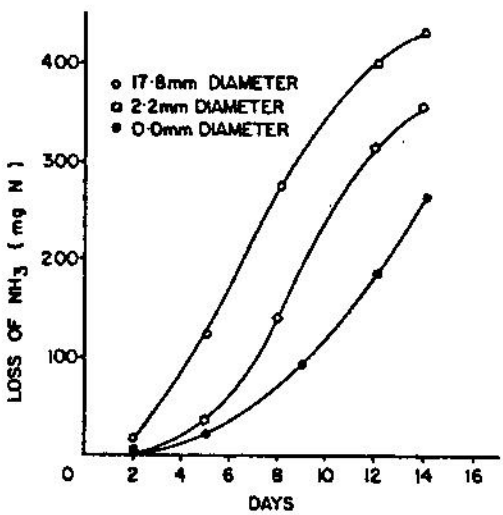

Fig. 2. Effect of size of urea granule on loss of ammonia.

Table 3. Effect of season on ammonia volatilization (% N) from urea

Time of sampling	Days		
	10	20	30
February	9.0	18.5	24.5
April	11.0	20.9	27.5
May	12.5	23.5	29.0
June	16.0	31.0	37.0
L.S.D. (P = 0.05)	3.2	5.6	7.5

As the size of granules increased, the loss of ammonia also increased (Fig. 2) because of higher rate of nitrogen application at the microsites in case of larger granules. In 7 days the cumulative loss of ammonia doubled as the size of granule increased from 2.2 to 17.8 mm. Fig. 3 shows a high positive correlation of loss of ammonia from the granules to square root of the diameter of the granule. On the basis of these results it could be concluded that urea granules bigger in size (Super granules) would not be suitable for alkaline calcareous soils.

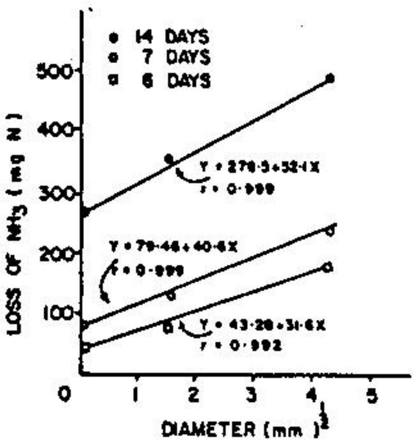

Fig. 3. Relationship between ammonia loss and $(\text{Diameter})^{\frac{1}{2}}$ of urea granule.

The hydrolysis of urea to ammonia is an important pathway of conversion of organic nitrogen to inorganic nitrogen in soils receiving application of urea. Urea hydrolysis could be catalyzed by extracellular urease adsorbed in soil (Pinck and Allison, 1961). The urease in soil is found within the cells of metabolising ureolytic microorganisms and plant organs and as an extracellular portion developed from ruptured morbid cells. Since extracellular urease is adsorbed on clay particles and humified organic matter (Pinck and Allison, 1961; Stojanovic, 1959), soils exhibit different levels of urease activity which would result in variable loss of ammonia in different soils. The results of ammonia loss presented here showed that factors like soil type, condition of soil, plant species, and seasonal temperature caused variations in the activity of urease enzyme and ammonia volatilization from urea in alluvial alkaline soils.

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