Changes in Soil Ph Resulting from Simulated Urine Patches

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Abstract

We examined possible causes of the soil pH changes and the rate of pH stratification development which occurs in urine patches. Sheep urine (11.6 g N/L) and urea solution (10 g N/L) were applied to soil in a pot experiment. Urea solution was used as a simplified urine substitute as the majority of urinary nitrogen is known to be present as urea. The changes in soil pH resulting from urea solution application were closely related to net changes in the concentrations of inorganic nitrogen fractions within the soil.

Keywords: soil pH, nitrogen transformation, urine, stratification, urea.

Many studies have investigated the cause and effect of soil acidification on agricultural production. Acidic layers within the surface 10 cm of soil profiles under crops and pastures in the Riverina (3, 5) have been identified. Convers and Scott (3) observed stratification of soil pH under subterranean clover within five years of initial soil mixing. Evans (5) reported the formation of such layers within one growing season under a wheat crop. The presence of acidic layers within the surface 10 cm of soil limits microbial processes such as mineralisation and nitrification (8, 10) and has the potential to decrease production.

The formation of acidic subsurface soil layers occurred after only five weeks following urine application (1). Nitrogen (N) transformations of the urine N, which are known to provide a source of acid to soil (7), were thought to be implicated in the formation of pH stratification. Doak (4) stated that greater than 75% of N in urine was urea. Thus we used an application of urea solution at similar concentrations to that in urine to estimate the N transformations which occurred within urine patches.

The objective of this study was to measure the short term transformations of N which occur in simulated urine patches and relate them to the soil pH changes in the surface 12 cm of soil.

Materials and methods

Soil was collected from the surface 10 cm of a Red Chromosol soil profile derived from granite. The site had been under pasture for a period of five years prior to sampling. Air dried soil was passed through an 8 mm sieve before being placed into cylindrical PVC pots (150 mm x 85 mm diameter). Three treatments were applied to the soil surface: a control of 25 mL deionised water, 25 mL sheep urine (11.6 g N/L) and 25 mL of urea solution (10 g N/L). Each treatment was replicated three times. All pots were maintained at 80% of field capacity and were kept in a glasshouse throughout the duration of the experiment.

Destructive sampling of the control and urea treated pots took place at days 0, 1, 3, 5, 8, and 32 while sampling of the urine treated pots occurred only at days 0, 8, and 32. Sampling involved dividing the pots into 2 cm depth intervals. Analyses of these samples included pH (0.01M CaCl₂), NH_4^+ and NO_3^- determination. Soil urea concentration and NH_3 volatilisation analyses were conducted until day 8.

Results and discussion

The resultant pH profiles that formed 32 days after urea or urine treatment application were not statistically different (P<0.01) except for the surface 0-2 cm layer where it was found that the pH of the urine treated soil was 0.8 pH units higher. This difference at day 32 may have been due to the difference in the initial pH of the urine and urea solutions (8.3 and 6.3, respectively) which were likely to have been caused by the hydrolysis of some urea in urine during urine collection. As the pH profile in the lower layers is indifferent between treatments it is assumed that the N transformations taking place were similar

in magnitude. Therefore it is likely that N transformations subsequent to hydrolysis were also similar in magnitude in the surface layer and that the initial pH of the applied solution was the cause of the soil pH variation between treatments in the 0-2 cm layer. As the higher initial pH of the urine was thought to be a product of collection and not of soil based processes, urea solutions were able to be used to adequately simulate the effects of urine.

Fig.1 illustrates the soil pH profile from urea treated pots as measured at various times throughout the duration of the experiment. The original pH of the soil was 5.2 however within 1 hour after treatment, the soil pH increased to the values shown as day 0. The pH continued to increase to a maximum at day 1. The soil pH profile then exhibited significant (P<0.05) decreases in the 0-2 cm layer with little change occurring at lower depths until day 8. During the time period between day 8 and day 32, all layers experienced significant acidification. The resultant soil pH profile at day 32 exhibited an acidic region within the 2-8 cm depth intervals which was similar to that reported by Black (1).



Figure 1: Soil pH (0.01M $CaCl_2$) profile of urea treated soil throughout the duration of the experiment. Bars indicate I.s.d (P<0.05).

Fig. 2a reports the net urea-N and NH_4^+ -N in the pots immediately after treatment application and 24 hours later. Net concentrations refer to those of the urea treatment minus those of the control. The increase in NH_4^+ -N concentration at day 1 is attributed to the hydrolysis of urea as it corresponded to an increase in soil pH over the same time period. The rapid increase in soil pH and NH_4^+ concentration created a chemical environment which promoted the onset of NH_3 volatilisation (2, 6). The volatilisation of NH_3 is an acidifying process and is thought to cause the decrease in soil pH in the 0-2 cm layer from day 1 to day 8. Watson and Lapins (9) also suggested that volatilisation of NH_3 was responsible for a decrease in soil pH after the initial increase due to urine application. At day 8, the rate of NH_3 volatilisation had decreased to below 1% of applied N/day and so subsequent acidification due to volatilisation would have been negligible.

Up until day 8 there was little production of NO_3^- . This suggests that nitrification had been inhibited by the soil conditions created by the hydrolysis of urea. This compares favourably with Doak (4) who implied that nitrate formation was inhibited by the elevated pH of the soil during the first week following urine application.

After day 8, the NH_4^+ concentration in the pots decreased whilst an equivalent increase in the NO_3^- concentration occurred (Fig. 2b). Nitrification had taken place and this was accompanied by the significant decrease in the pH of all layers from day 8 to day 32 (Fig. 1).



Figure 2: The net urea-N and NH_4^+ -N concentrations of urea treated soil on a per pot basis at days 0 and 1 (a), and net NH_4^+ -N and NO_3^- -N concentrations of urea treated soil on a per pot basis at days 8 and 32 (b). Bars represent standard errors.

In conclusion, the soil pH changes that occur within a profile as a result of urine or urea application are closely implicated with the timing and nature of the N transformations which take place. It follows that the magnitude and rate of pH change within various layers of the surface 10 cm of soil are influenced by the location and concentrations of various N fractions present.

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