MONITORING THE MOVEMENT OF N AND S THROUGH THE SOIL-PLANT-ANIMAL SYSTEM UNDER DEGRADED AND PERENNIAL PASTURES

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ABSTRACT

An experiment was carried at Armidale, NSW, Australia, to test the hypothesis that pastures dominated by the perennial grass phalaris (*Phalaris aquatica*) together with white clover (*Trifolium repens*) can optimize nutrient cycling and minimize nutrient leakage in comparison with one where the perennial grass has been lost through prior overgrazing (‘degraded’). The concentrations of mineral nitrogen present as ammonium and nitrate indicated limited opportunities for N leaching under either perennial or ‘degraded’ pastures in this environment. The high S content in the 40-60 cm soil layer indicates some movement of S under both ‘degraded’ and perennial pastures.

KEYWORDS

Nitrogen, sulfur, leaching and perennial pastures

INTRODUCTION

Temperate pastures are an very important resource for both wool and meat production in the high rainfall zone of Australia. The decline of perennial grasses in pastures in temperate Australia is becoming a problem, because this decline is directly related to economic loss and potentially increased water and nutrient leakages from the system. It has been estimated that there has been a 10 to 20% decline in wool production associated with the loss of sown perennials (Hutchinson, 1993). The early research in this site showed no change in pH indicating closed N cycling (Duncan, 1980). The main objective of this research is to test the hypothesis that pasture dominated by phalaris and white clover can optimize nutrient cycling and minimize nutrient leakage in comparison with one where the sown perennials have been lost through prior overgrazing.

MATERIALS AND METHODS

The experimental site is located at Armidale, NSW, Australia (30°36'S, 151°32'E; elevation 1046 m). There are three treatments: Phalaris dominant, white clover/phalaris and ‘degraded’(where the phalaris component has been lost through overgrazing) with two replicates. Six 1m x 0.5m labeled areas were established within each of the 6 experimental plots. The pasture was clipped to 2 cm and a solution of $^{15}NH_4Cl$ spread over each labeled area. ^{34}S enriched (98%) elemental sulfur was ground to pass through a 250 (m sieve, 50 mg of ^{34}S was mixed with 30g sand (<250 µm) and spread by hand on each labeled area. These applications were equivalent to 1 kg N/ha and 1 kg S/ha and thus had only a minor effect on N and S dynamics, but provide a pulse of N and S which can be measured as it moves through the soil-plant-animal system. In this paper, data for mineral N and S through the soil profile over two sampling times are represented. Mineral nitrogen (nitrate and ammonium) was analyzed in 2M KCl (Page *et al*., 1982). Mineral S was extracted by 0.25M KCl at 40°C (Blair *et al*., 1991). This soil test extracts the available soil sulphate and the readily mineralisable organic sulfur.

RESULTS

Total mineral nitrogen was in the range of 7.7-18.4 mg/kg in the 0-5 cm layer at the beginning of the experiment (30/5/95). Total soil mineral nitrogen in phalaris/white clover pasture was significantly higher than in the other two pastures, and there was no significant difference between the ‘degraded’ and phalaris dominant pastures (Fig 1). In general, the top 0-5 cm soil layer was ammonium-dominated in all pastures. The proportion of mineral nitrogen as ammonium decreased as soil depths increased, such that all treatments were nitrate dominant below 5 cm. The subsoil (5-20 cm) nitrate in the phalaris/white clover pasture was significantly higher than in the other two pastures. By the sixth sampling (13/6/96), the concentration of mineral nitrogen in the top 5 cm decreased for all three pastures and there was no significant difference between the three treatments. In contrast to the May sampling, the top 0-5 cm soil layers were nitrate-dominated in all pastures. Nitrate made up 64%, 56% and 54% of total soil mineral nitrogen in the ‘degraded’, phalaris dominant and phalaris/white clover pastures respectively. However, the nitrate concentration decreased significantly as soil depth increased; as a result, all treatments were ammonium-dominated below 10 cm (Fig 1). The extractable sulfur content of the topsoil at the first sampling was in the range of 10.9-14.0 mg/kg. The sulfur content of phalaris/white clover pasture was significantly higher than that in the ‘degraded’ pasture. Unlike mineral nitrogen, there was a gradual decrease in S content down the soil profile for all pastures. By the sixth sampling, the sulfur content was in the range of 10.2-12.0 mg/kg in the top 0-5 cm, and there was no significant difference between the three treatments. However, the sulfur content for all pastures decreased gradually in the 5-40 cm soil layer and then increased significantly in the 40-60 cm soil layer. Sulfur content in the 40-60 cm soil layer was significant higher than the top soil for all three pastures (Fig 2).

DISCUSSION

Understanding the dynamics of nutrient transformations (N and S) in soil is very important in coming to understand soil-plant-animal systems . This information could help us to assess whether a system has nutrient leakage potential under certain environmental conditions. In this study, changes in total mineral nitrogen present as ammonium and nitrate over two samplings were associated with the seasonal differences. In this environment, where rainfall is summer dominant, total mineral nitrogen and nitrate levels increased as temperature increased until the middle of the summer such that the top 0-5 cm soil layer was nitrate-dominated in the summer and ammonium dominated in the autumn and winter (Chen, 1996 unpublished data). The published data also indicates that high temperature, together with high rainfall provide the optimum conditions for N mineralisation and nitrification (Whitehead, 1995). The distribution of mineral nitrogen as ammonium and nitrate through the soil profile, also varied with the seasons and soil moisture (Chen, 1996 unpublished data). The nitrate dominance in the sub-soil in the autumn and ammonium dominance in the summer, were associated with the dry autumn and the wet summer. In general N mineralisation and nitrification rates, as indicated by high mineral nitrogen and nitrate levels (Chen, 1996 unpublished data), seem to match well with N demand of pastures as pastures also grew vigorously until the middle of the summer in this environment, therefore, N loss through nitrate leaching was very limited. The use 15N confirmed this finding (Chen, 1996 unpublished data). The extractable sulfur content of the top 0-5 cm soil layer was higher than the critical level suggested for this soil test (approximately 6 ug/g. soil). Unlike mineral nitrogen, there was only a small decrease in S content down the soil profile to the 20cm soil layer. However, the S content in the 40-60 cm soil layer for all pastures was significantly higher than the top 0-5 cm layer. The high level of S in the 40-60 cm soil layer was associated with the previous long-term fertilizer applications in these plots, and indicates some movement after many years of S application.

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Figure 1
Total mineral nitrogen (nitrate and ammonium) at different soil depths in the three pasture types over two sampling times.

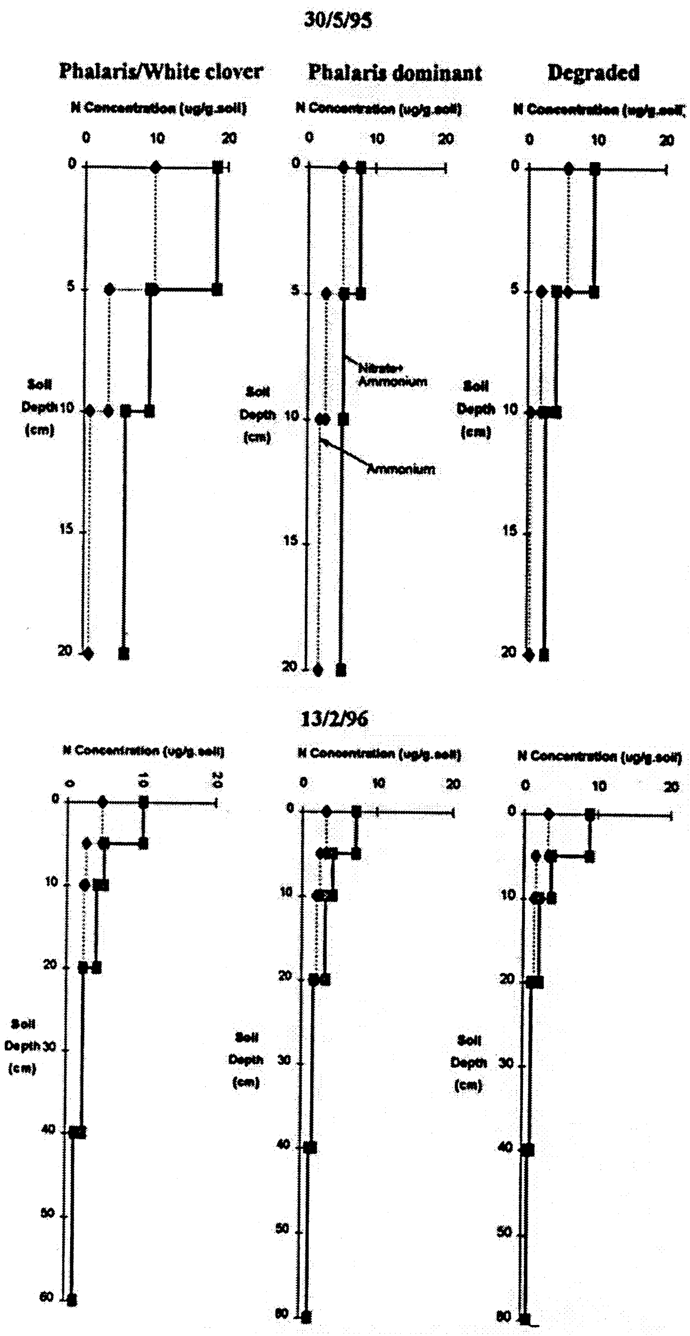

Figure 2
Sulphur concentration at different soil depths in the three pasture types over two sampling times.