FACTORS INFLUENCING THE TRANSFORMATION AND FATE OF SULPHUR AND NITROGEN IN GRAZED HILL COUNTRY PASTURES

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ABSTRACT

The increasing cost of agricultural grade sulphur and the high leaching losses of sulphate sulphur(S) from superphosphate fertilized pastures in New Zealand create a need to develop more efficient S fertilization techniques. The objective of the present study was to identify the main origins of the sulphate being leached from superphosphate fertilized hill country pastures with soils (Typic Dystrachrepts) developed from underlying sedimentary parent materials.

Origins of leached sulphate were categorized as S leached directly from fertilizer, from zones enriched in animal excreta and from the mineralization of soil organic matter. Mineralization studies, both in laboratory and in field were conducted to establish the extent of and the relationship between sulphur and nitrogen mineralization and the fate of mineralized nutrients in pasture soils that contrasted in their superphosphate fertilizer history.

In the preliminary laboratory study in which an open incubation technique was used to measure potential net mineralization, top soils (0-7.5cm) taken from sites that had received higher rates of superphosphate in the past, mineralized more soil organic sulphur and nitrogen than soils taken from sites that had received smaller amounts of superphosphate in the past. In addition top soils collected from low slope (0-12°) sites where a greater proportion of animal excreta is returned, mineralized more S and N than the soils from medium slope (13-25°) sites. The ratio of N to S mineralized was narrower (2.0 to 3.6) than the N to S ratio of the whole soil (7.1 to 8.9) suggesting that in these soils relatively more S remains in a mineral form in the soil and is more susceptible to leaching than N which is conserved in the soil.

Cylindrical, mini-lysimeters with ion exchange resin traps for collecting solutes from drainage water were developed to measure the net mineralization of soil organic S and N under field conditions. Leaching losses of S and N, pasture uptake of S and N and changes in mineral S and N pools in the soil at the same site were measured simultaneously and the rate of mineralization calculated. A laboratory evaluation of the lysimeter showed that the resin trap was capable of removing all the sulphate from

drainage water at several different flow rates. The main advantage of these lysimeters over the conventional methods of measuring the leaching losses of anions and cations in the field is that regular drainage collection was not necessary. By introducing mixtures of both anion and cation exchange resins in the trap in the lysimeter it was possible to monitor the amount of anions and cations in field drainage over long periods of time before it was necessary to change the resin mixtures.

In the initial field lysimeter study the net mineralization and pasture uptake of N (119 to 251 kg N ha^{-1}) was 10 times more than that of S (12 to 27.5 kg S ha^{-1}), yet approximately 10 times more sulphate S (2.0 to 17.3 kg S ha^{-1}) than mineral N (0.19 to 1.3 kg N ha^{-1}) was lost by leaching. Previous fertilizer history had a marked effect on the leaching losses of sulphate with seven times more S lost (2.1 vs 15.3 kg S ha^{-1}) from sites which received greater rates of superphosphate and had higher stocking rates. During the initial seven month period S leaching losses on the low and high fertility sites were equivalent to 15% and 33% of the annual fertilizer application. More sulphate was leached from areas identified as animal camping areas. The lack of any change in sulphate below the 150mm soil depth during a period of active plant growth and no leaching suggested that any sulphate that moved below 150mm of the soil could be considered to be effectively lost from the system. Increased leaching losses of calcium and magnesium were associated with increased sulphate losses. The amount of calcium lost by leaching (4.75 to 12.5 kg Ca ha^{-1}) was far greater than potassium (0.8 to 3.6 kg K ha^{-1}), although twice the amount of potassium (240 kg K ha^{-1} vs 120 kg Ca ha^{-1}) was cycled through the plant-animal system. The amount of magnesium lost by leaching was greater than the amount of potassium lost by leaching.

In a second lysimeter study the direct effects of freshly applied fertilizer on the mineralization of S and N from soil organic matter, their plant availability and losses by leaching were studied under field conditions using ^{35}S labelled superphosphate. Fertilizer application significantly increased the mineralization of both organic S and N. The recovery and measurement of ^{35}S activity over a nine month period showed that major proportions of pasture S (85 and 86% of the pasture S for low and high fertility farmlets, respectively) and leached S (75 and 87% of the leached S for low the mineralization of soil organic matter and not recently applied fertilizer. The amounts of both S and N mineralized from soil organic matter depends upon the past fertilizer history of the site and the present fertilizer application rate (22 and 40 kg S ha^{-1} and 125 and 204 kg N ha^{-1} for low and high fertility farmlets, respectively). Further, when the net mineralization of S was greater a greater proportion (59%) of mineralized S was lost by leaching than removed by pasture (39%). Irrespective of the amount N mineralized virtually all was removed by pasture. The results suggested that low N availability was a major factor limiting carbon fixation and the formation of organic S in these pasture soils.

In a third lysimeter study, field simulated sheep dung and urine events boosted pasture growth and S and N uptake by approximately (50%), whereas the leaching losses of S and N were not influenced by the their application.

A preliminary computer simulation model describing the mineralization of soil organic S, pasture S uptake and leaching losses in grazed pasture was developed. The preliminary model gave reasonable predictions of the changes in soil sulphate concentrations in the soil up to a depth of 25cm, pasture uptake of S and leaching losses of S at four pasture sites varying in their fertilizer history. Further refinement of the model is necessary before it can provide the basis for predicting fertilizer S requirement for hill country pastures.

The experimental results and model output confirm balance study predictions that large leaching losses of S occur and these are derived mainly from the mineralization of soil organic matter which accumulates in well fertilized soils. The extent of S losses appear to be a function of the general levels of soil productivity and the data suggested that only a small, probably less than 20% reduction in this loss could be achieved by changing to slow release S fertilizers.

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