DYNAMICS OF NITROGEN IN THREE CONTRASTING PASTURES GRAZED BY SHEEP

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ABSTRACT

The dynamics of nitrogen (N) were studied during two years (March 1989 - May 1991) in three contrasting pastures grazed by sheep. The pastures were: ryegrass-white clover, herbal ley (a legume-based pasture of interest for "organic" agriculture) and pure ryegrass receiving 400 kg fertiliser N/ha/yr.

This study was undertaken on a recent alluvial soil at DSIR Grasslands, Palmerston North. Treatments were replicated as small paddocks, and periodically mob-grazed with sheep. Frequent soil measurements provided estimates for leaching and denitrification. Herbage yields and botanical composition were recorded, and symbiotic N_2 fixation was measured in swards of the two treatments containing forage legumes. Soil total N and carbon were measured annually, providing estimates of the partial mass balance for N.

The soil mineral N pool was dominated (especially in the systems receiving no fertiliser N) by the highly concentrated pulse of N returned in the excreta of grazing animals to a small proportion of the grazed area. In the pure grass sward the large inputs of fertiliser N had a significant effect in increasing the amount of mineral N available in the top 45 cm of soil. On average, in composite samples including urine-affected and non-affected areas, about 30 kg/ha-45 cm more mineral N was available throughout the year in the ryegrass fertilised with N than in the legume-based pastures. This consistently high level of soil mineral N in the ryegrass+N sward was responsible for the greatest annual herbage yield; however annual losses by leaching and denitrification were 5 to 6 times greater than in the legueme-based pastures.

A common feature of the three pastures was the small amount of N recovered in animal products, with most of the N that circulated through the plant to the sheep being returned to the soil in urine. This concentrated input was localised in about 10% of the area, which provided the major avenues for N

escape from the pastures receiving no fertiliser N. It was estimated that a little more than half the nitrate leached (total, about 6 kg NO_3-N/ha/yr) arose from this restricted area, but in the grass+N pasture the contribution of animal-induced losses was proportionally smaller than in the legume-based pastures. Fertiliser N, by increasing soil mineral N, offered more site opportunities for N leaching and denitrification, in addition to that from urine. Here, only one-quarter of leached nitrate (total, 41 kg NO_3-N/ha/yr) arose from urine patches. Denitrification accounted for 4-5 kg N/ha/yr from the legume-based pastures, but 20 kg N/ha/yr from swards receiving fertiliser N. Ammonia volatilisation, which was estimated using data from previous studies at this site, was enhanced by direct emission from the fertiliser N (urea) as it is hydrolysed on the soil surface.

Calculation of N inputs and outputs for these three pastures indicated that the two legume-based systems were more or less in balance, but in the pasture receiving fertiliser N some 180 kg N/ha/yr was unaccounted for. This difference may reflect incorporation of N into soil organic matter, as indicated by a small increase in soil total N during the second year.

Pasture production (average of two years) from the herbal ley was about 15 t DM/ha/yr, or about 90% of the yield from pasture receiving fertiliser N, and some 25-30% more than from ryegrass-clover. Symbiotic N_2 fixation, estimated by the acetylene reduction assay to have been 140-150 kg N/ha/yr, was similar in both systems based on forage legumes. The herbal ley utilised soil N more efficiently than the ryegrass-clover and ryegrass+N pastures, hence achieving an outstanding yield of herbage. It is argued that this apparently better exploitation of soil N was brought about largely by stimulation of microbial biomass in the rhizosphere around chicory roots, with the additional N that was scavenged by bacteria being made available to this herb after protozoan digestion of the bacteria. A herbal ley offers the possibility of sustaining a high level of forage production, but with reduced N emissions to the environment.

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DEDICATION

This work is dedicated to my immediate family, wife Isabel son Gonzalo and daughter Pilar. Also to my parents, especially to the memory of my late father, who died while I was studying in New Zealand.

TABLE OF CONTENTS

CHAPTER 4

MINERAL NITROGEN

CHAPTER 5

NITRATE LEACHING

CHAPTER 6

DENITRIFICATION

LIST OF FIGURES

LIST OF TABLES

APPENDICES