PHOSPHATE CYCLING IN GRAZED HILL-COUNTRY PASTURE

A thesis presented in partial fulfillment of

the requirements for the degree of

Doctor of Philosophy in Soil Science

at Massey University

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1987

ABSTRACT

A detailed study of the "above-" and "below-ground" components of the phosphorus (P) cycle was carried out in the North Island hill country of New Zealand. The effect of P fertiliser rate and degree of land-slope on pasture P uptake, faecal P return and changes in soil P fractions was examined over a three year period.

Plant P uptake was found to decrease with increasing slope and increase with increasing rate of P fertiliser. The changes in plant P uptake were a function of changes in both dry matter yield and pasture P concentration. Pasture on campsites which initially had a high Olsen P status (>30) showed an unexpected apparent P response in both dry matter yield and plant P uptake. This response results from an artefact of the trial design whereby P fertiliser was applied to whole paddocks. The resulting improved nitrogen status of slopes at high rates of P fertiliser created abnormally high soil nitrogen levels on campsites, leading to very high levels of production. These findings are of significance in relation to soil fertility field trials conducted on individual slopes in hill country. Over the three year period of the trial seasonal plant P uptake followed the order: spring ≥ summer > autumn > winter, irrespective of slope category, fertiliser rate or grazing regime.

The distribution of faecal material was found to be markedly affected by slope and approximately 60% of the material deposited in each paddock was returned to campsites. In the remainder of the paddock,

faecal P return decreased by at least 50% with each 10° increase in slope.

Paddock faecal P concentration (FP%) was predicted from the pre-grazed pasture P concentration (PP%) (calculated on a paddock basis) using the relationship:

$$FP\% = 3.19\ PP\% - 0.09\ (r = 0.94\ **).$$

Net P balance calculations for various slope group categories showed that deficits between plant P uptake and faecal P return increased with increasing slope but were little affected by increasing P fertiliser rate and consequent increase in stocking rate. This finding verifies the use of a single animal loss factor for a given topography, irrespective of sheep stocking rate, in the Ministry of Agriculture's (MAF's) Computerised Fertiliser Advisory Scheme (CFAS) for P.

Measurements of faecal distribution in this trial suggested the use of a lower animal loss factor (0.5 kg su^{-1} of P) for "Easy" hill country than that used currently (0.7 kg su^{-1} of P) in the CFAS model.

Independent studies on the rate of P cycling from faeces were conducted. The study investigating breakdown of faecal material revealed that physical disintegration of faecal material is likely to occur before chemical decomposition. In winter conditions faecal material disintegrated within a month; in summer conditions disintegration took approximately three months. In both seasons material on campsites disintegrated more rapidly than that on steeper slopes.

A further study using radioisotopes in the field found that the short-term plant availability of inorganic faecal P was approximately half that of monocalcium phosphate fertiliser over a two month period in the spring.

In a study on the "below-ground" components of the P cycle total soil P was found to increase with increasing rate of P fertiliser. The magnitude of these increases decreased with increasing slope and depth.

Increases in organic P were found to be higher on campsites than steeper slopes. On campsites, the extent of increase in organic P decreased with increasing rate of P fertiliser.

Inorganic P increased with increasing rate of P fertiliser on all slopes; the magnitude of the increase decreased with increasing slope. At low rates of P fertiliser a decrease in inorganic P was measured on steep-slopes over time indicating that P inputs were not balancing P outputs.

A change in the non-occluded P fraction accounted for the greatest proportion of the change in inorganic P on most slopes. The fact that calcium-bound P accumulated on all slopes, and that large increases were evident at high rates of P fertiliser suggested that this fraction was not playing an active part in the P cycle but was accumulating as an insoluble residue from superphosphate.

The plant availability of soil P fractions was investigated in a glasshouse study. Total plant P uptake was found to be highly correlated with initial levels of total P (r = 0.92),non-occluded P (r = 0.82), inorganic P (r = 0.91), Olsen P (r = 0.93) and water-extractable P (r = 0.97). Levels of organic P, occluded P and calcium-bound P were found to be essentially unchanged by plant growth over the eleven month trial period.

Changes in the size of the cycling soil P pool were examined by combining results from the field trial with those from the glasshouse study. At low rates of P fertiliser (10 kg ha^{-1}), increases in occluded P and calcium-bound P (i.e., unavailable inorganic P) in the 0-15 cm depth were occurring at the expense of available P. At a high rate of P fertiliser (100 kg ha^{-1}) approximately two thirds of the P applied remained in the available form.

On an annual basis, Olsen P increased with an increasing rate of P fertiliser and decreased with increasing soil depth and slope. Over the period of the trial Olsen P decreased significantly at the lowest rate of P fertiliser (10 kg ha^{-1}) and increased significantly at the highest rate (100 kg ha^{-1}) on the two slope groups studied. This indicated that these areas were not at "equilibrium" as defined by a stable Olsen P. At moderate rates of P fertiliser (20 and 30 kg ha^{-1})

it was not possible to determine whether or not equilibrium conditions existed as the annual variability in Olsen P was too high.

An attempt was made to determine soil P losses (as defined by the CFAS model) at the trial site. Despite intensive and careful soil sampling Olsen P could not be used to determine "equilibrium" conditions which are a pre-requisite for measurement of soil P loss. This finding prevented validation of soil loss factors on this hill-country site.

Data generated from the large field trial for "above-" and "below-ground" components of the P cycle enabled recommendations to be made on the location of suitable soil sampling sites and also on the location of priority areas for application of P fertiliser in grazed hill country.

ACKNOWLEDGEMENTS

I would like to express my heartfelt gratitude to the following people:

Professor Keith Syers for the stimulation provided by his enthusiasm.

Dr Paul Gregg for his practical outlook and discerning comments, particularly towards the end of the project.

Mr Russell Tillman for his endless patience, support, encouragement and understanding.

Dr Allan Gillingham for valuable discussions and assistance at all stages.

Miss Sandy Dixon, Mr Lance Currie, Mr Martin Eggels and Mr Martin Lewis for technical assistance at different stages of the project.

Past and present members of the Soil Science Department who have offered friendship, encouragement and assistance throughout.

Miss Sue Jolly, Mrs Prue Williams and Ms Heather Meikle for their friendship and their work in referencing, proof-reading and producing this thesis.

Mrs Heather Murphy for the plotting of superb diagrams.

Mrs Alex McGarry and Mrs Ann Rouse for their patience in typing and retyping.

The University Grants Committee for a UGC Scholarship, Massey University for the MacMillan Brown Agricultural Research Scholarship and the Ministry of Agriculture and Fisheries for funding of the project.

John and Virginia Muirhead and Vaughan Hickson for support, encouragement and friendship through all travail.

Finally, my family, without whom my ***magnum opus*** would not exist.

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