AN INTEGRATED SOIL TESTING - MODELLING APPROACH TO IMPROVE FERTILISER RECOMMENDATIONS FOR GRASSLAND.

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ABSTRACT
New management strategies are required in order to reduce the appreciable emissions of N from intensively managed grassland. Previous work has shown that if fertiliser is applied at rates that take account of the mineral N found in soil at the time of each application, N use efficiency can be improved. A novel approach is described which integrates soil testing and modelling to produce N fertiliser recommendations on a monthly basis. An existing annual model of the N cycle in grassland has been modified to produce monthly predictions of mineral N in the soil. The model is being validated by data from a replicated cut plot experiment at 3 sites.

KEYWORDS
Fertiliser, nitrogen, rapid test, mineral N, environment.

INTRODUCTION

Emissions of N from intensively managed grassland may be as great as, or greater than, those from arable cropping systems (Ryden et al., 1984). There is an urgent need, therefore, to improve the efficiency of N use in order to decrease emissions and yet to maintain economic levels of production. One way of increasing efficiency would be to adjust fertiliser inputs to take account of N supplied through mineralisation, fixation by legumes and atmospheric deposition, and also the influence of weather on uptake of N by the plant. Because of the complexity of the N cycle, the optimisation of N supply for a given level of herbage production, and the associated loss of N, can best be achieved through the application of an appropriate model. However, frequent checks on the outcome of supply of and demand for soil mineral N may be made using a field test.

This paper describes the integration of modelling and soil testing as a basis for improved fertiliser recommendations that can prescribe for both economic and environmental goals. The model is used to derive recommendations for 3 specified levels of output at each of 3 sites located in the west of England. Effects of the recommendations on N pools are presented and compared with model predictions for one of the sites during Spring 1996.

METHODS

Modelling: The model used is a modification of the empirical annual mass-balance model 'NCYCLE' (Scholefield et al., 1991). A shorter time step version has been created by distributing the annual totals according to weighting factors derived from multi-site grassland cutting trials, long term measurements of mineralisation and denitrification, and long-term average monthly weather data for each climatic zone. For any site, with a specific set of input values, a mineral N profile is produced (Figure 1). This represents the amount of mineral N already in the soil, and the mineral N predicted to be required to reach the target plant yield for the given month. The difference between these two N levels is the recommended fertiliser input for that month.

Experimental: Site 1 is on a poorly drained silty clay loam (Stagno-dystric gleysol) and has a 40 year old sward, with a reseeded sward for comparison. The average annual rainfall is 1025 mm. Three blocks of 8 randomised plots (3 x 10 m) on a 5° slope were hydrologically isolated to 30 cm, to determine N loss in runoff and surface lateral flow (known to be the dominant drainage route at the site), using a tipping bucket assembly with flow-proportional sampler. Site 2 has a well-drained sandy loam (Dystric Eutrocrept) with a sward age of 2 years, average rainfall as site 1. Site 3 is on a sandy soil (Newport series), with an annual rainfall of 750 mm. At sites 2 and 3, ceramic suction-cup samplers were installed to 90 cm depth, to monitor nitrate leaching.

At all sites, 4 fertiliser treatments are imposed; 3 according to model-produced profiles, representing low, medium and high annual fertiliser use (approximately 150, 340 and 600 kg N ha^{-1} yr^{-1} respectively), and a conventional treatment, adhering to current recommendations for N fertiliser application to grassland. Monthly assessments of mineral N, denitrification (after Ryden et al., 1987), mineralisation (after Hatch et al., 1990), dry matter and plant N yield are made. Soil testing is undertaken using the 'Rapid N test', which uses a hand-held battery-operated reflectometer ('NITRACHECK', QuoMed Ltd, Horsham, Surrey, UK) with ion-sensitive paper strips, (Scholefield and Titchen, 1995) to facilitate unbiased estimation of intensity of colour.

RESULTS AND DISCUSSION

Table 1 shows that predicted mineral N was slightly greater than observed in all three months. In most cases the model predictions of monthly denitrification were not realised. This can be attributed in part to the lower than average soil temperature, particularly in April (4.76° C compared to the 30-year average of 7° C). In May, the effect of the lower than average temperature was counterbalanced to a degree by the lower than average soil moisture deficit. The denitrification model is sensitive to water-filled pore space, which in May was higher than predicted (86% compared to a prediction of 74%).

Mineralisation in each month was under-predicted by the model (table 1). This cannot be explained by the deviation of climatic variables from the norm. A possible explanation is the increase in aeration of the soil which occurs during sampling and incubation, which may be alleviated to some extent by the use of sheathed cores.

It is anticipated that the integrated modelling/soil testing approach will improve the efficiency of N use. The data for the first 3 months of monitoring suggest that the model is under-predicting mineralisation and over-predicting denitrification. This is partly due to the climatic conditions in these 3 months, compared to the long-term averages. In order to make an evaluation of the performance of the model, and the feasibility of the integrated approach, predictions need to be validated for the whole experimental period, at all sites.

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Table 1
Comparison of predicted and observed N flux and dry matter yield for an example treatment (Annual fertiliser input = 150 kg N ha^{-1}, reseeded sward, site 1), for 3 months in 1996.

	APRIL		**MAY**		**JUNE**	
Fertiliser input (kg N ha^{-1})	48		57		17	
	Predicted	Observed	Predicted	Observed	Predicted	Observed
Soil Mineral N (kg N ha^{-1})	10	5.98	10	7.84	10	9.02
Dry matter yield (kg ha^{-1})	1686	1175	2105.4	1786.2	1174.32	1035.19
Denitrification (kg N ha^{-1})	9.24	1.43	11.48	12.78	2.97	2.24
Mineralisation (kg N ha^{-1})	16.77	22.4	24.72	26.32	26.7	40.87

Figure 1
Mineral N profile for low fertiliser input, reseeded sward, site 1.