Utilising the concept of nutrients as a currency within organic farming system

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ABSTRACT

Within organic systems, the successful management of nutrients at the field level is crucial for maximising production and minimising the environmental impacts. This requires that the farmer makes the best possible use of nutrients excreted by the grazing or housed livestock. In addition, the farmer must successfully manage the nutrients built-up in the ley phase of the crop rotation over the whole of the arable phase period. To analyse these complex flows, a nutrient budget model has been developed that describes the spatial and temporal flows within the organic farming system. The concept is analogous to treating nutrients as a currency where the flow of nutrients represents a cashflow. A spatial nutrient budget permits the analyses of the performance of the nutrient flows to be examined for the housing, manure, livestock, rotational land and permanent pasture to be analysed separately. This analysis will allow the farmer to better understand the weaknesses in the system, and hence take preventative measures.

Keywords: nutrient budget; currency; spatial; temporal; resource use

INTRODUCTION

The management of nutrients within organic systems is crucial for maximising production and minimising the environmental impacts, which arise from nutrient losses. However, this requires the successful management of nutrients not only at the farm-gate level, but also within the farming system. Hence, the farmer has a need to understand the nutrient flows within the crop rotations as well as the permanent pasture. In addition, an understanding is required of how the nutrients contained in the faeces and urine excreted by grazing or housed livestock and utilised within the system impact on both production and nutrient loss. The successful management of nutrients requires that the organic farmer exploit the nutrients built-up in the ley phase of the crop rotation over the whole of the arable phase. Consequently, successful nutrient management requires both a spatial and temporal understanding of nutrient flows. Hence, to analyse these complex flows, a nutrient budget model has been developed that describes the spatial and temporal flows within the organic farming system. The concept of the nutrient budget is analogous to treating nutrients as a currency with the nutrients flows representing cashflows, and the inputs and outputs of nutrients from the system are equivalent to income and expenditure respectively. Hence, the farmer can analyse the system in terms of both the monetary and nutrient currencies with the objective of maximising financial surplus and breaking even in terms of nutrients.

This paper describes the nutrient budget model and assumptions used to describe the possible potential flows of nitrogen within the system and the linkage to cashflows.

THE NUTRIENT BUDGET MODEL

Similarly to an annual cash flow, which describes the flow of cash into and out from a business (Warren, 1992), a nutrient budget describes the flows of nutrients into and out from a farm. In the same way that a cash flow can be determined for each enterprise within the farm business, nutrient budgets can also be calculated for each enterprise. However, to extend the principles of enterprise cash flows to nutrient budgets, a systems budgeting approach (Jarvis, 1999) must be adopted. Accordingly, the inputs and outputs from the system are described on a field-by-field basis, and for each livestock building. These elements are then aggregated to consider the whole farm. A schematic diagram (Figure 1) illustrates the flows considered by the model.

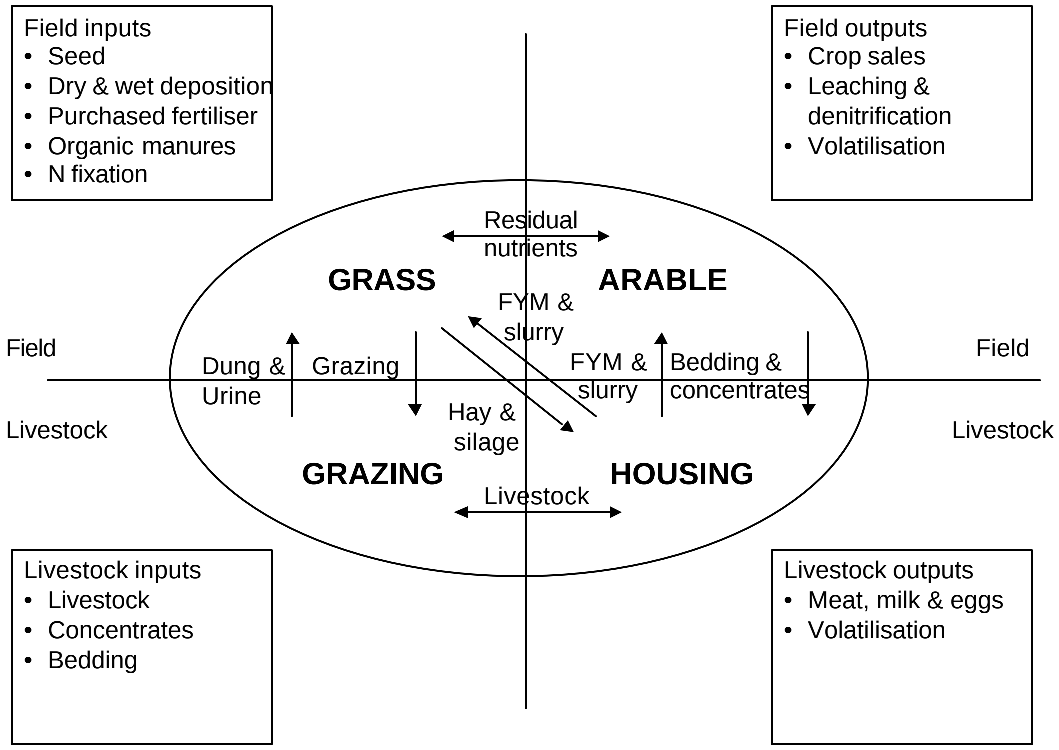

Figure 1. A schematic diagram of the integrated model

The farmer/advisor enters details on a field-by-field basis that describe the quantities of seed, organic fertilisers/manures that have been applied to each field. The assumed losses of nutrients from the manures and slurries are based on those described by Dyson (1992), and hence the timing of application, the application method and the type of storage all influence the nutrients available to the crop. The nitrogen fixation by legumes is dependent on the percentage cover of legume in the sward, which is converted to a dry matter basis (Kristensen *et al.,* 1985), the age of the ley, and the quantity of nitrogen applied as slurry/manure or fertiliser (Korsaeth & Eltun R, 2000).

The farmer also enters information describing the number of grazing days for each livestock type for each paddock and quantity of additional feedingstuffs fed to the livestock. Following Topp & Doyle (1996), the intake of forage, and hence the intake of nutrients is determined. It is assumed that the nutrients excreted by the grazing animal are equal to nutrient intake less the nutrients contained in the weight gain and in the case of lactating animals, the nutrients contained in the milk. The intake of forage and additional feedingstuffs of housed animals are entered by the farmer/advisor.

The calculation of nitrogen mineralised from the soil pool is based on simulations using the N-Cycle model (Scholefield *et al.*, 1991). The wet and dry deposition values are default look-up values and are dependent on the location of the farm. The farmer/advisor enters the yield of crop harvested and whether or not the residual yield is removed and other information on the purchases and sales.

In the model, the volatilisation losses of nitrogen from slurry/manure and the grazing animal are described, and are attributed to the location where the loss occurred. The leaching and denitrification losses are equal to the inputs minus the outputs, with the available nitrogen from the slurries/manure and defecation from the grazing animal corrected for volatilisation losses. Hence, the total losses for each part of the farm are assumed to be the sum of the losses from leaching, denitrification and volatilisation. The change in the soil nitrogen pool is the input minus the output and losses from the system. In the case of the slurries/manures and excreted nitrogen inputs, the total nitrogen value is described as opposed to the available nitrogen figure.

RESULTS

The nitrogen budget was used to assess the flows of nitrogen within the SAC organic unit at Woodside, Grampian (National Grid Reference 170624). The farm consists of arable land and permanent pasture, with the arable land representing 74% of the land area. Hence, as the flows are calculated on a field-by-field basis this allows the efficiency and the losses to be attributed to the various parts of the farm (Figure 2).

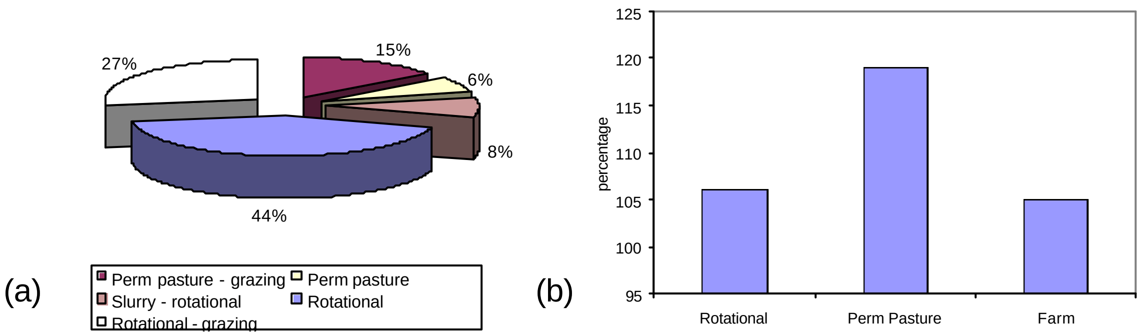

Figure 2. (a) The distribution of the losses and (b) the ratio of inputs–outputs for the rotational land, permanent pasture, and the farm

The results indicate that the performance of the arable and permanent pasture areas of the farm differ, and additionally, the losses that are occurring can be partitioned so that an assessment can be made of how to reduce these losses and where actions need to be taken. This is analogous to the farmer analysing the financial cashflows to assess the strengths and weaknesses of the business.

DISCUSSION AND CONCLUSION

The nutrient budget model is a useful tool for analysing the nutrient flows with the system. As the model is both spatial and temporal, phases in the rotation that are mining the soil or resulting in large losses can be identified. It is also possible to assess where the losses are occurring and if certain parts of the farm are out of balance. The model describes the inputs and outputs for each part of the system, and hence is analogous to the farmer/advisor preparing a cash flow for each part of the system. In addition, as the farmer/advisor analyses the financial strengths and weaknesses of the business, the nutrient strengths and weakness can also be assessed and corrective action taken. 'What-if' scenarios allow the farmer/advisor to predict the nutrient balances and losses and hence take corrective action in the same way as farmers currently use cashflow predictions.

ACKNOWLEDGEMENTS

The work described here was carried out as part of a linked program of research between SAC and IACR-Rothamsted. We are grateful to the Scottish Executive Environment and Rural Affairs Department, Department of Environment, Food and Rural Affairs, and the UK Biotechnology and Biological Sciences Research Council for funding this research programme.

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From: Powell et al. (eds), ***UK Organic Research 2002: Proceedings of the COR Conference, 26-28th March 2002, Aberystwyth*****, pp. 157-160.**