Sustainable Nutrient Cycling in Crop/Livestock Systems

Experimental and simulation modelling techniques were used to examine the implications of changes in nitrogen dynamics in animals on the behaviour of nitrogen in soils to which their excreta have been added, and on the resultant growth of plants on these soils.

Background

The importance of nitrogen cycling in the mixed farming systems of sub-Saharan Africa and other developing countries has received only patchy attention from researchers and development planners. Minimising nutrient losses through promoting effective recycling of nitrogen (and other nutrients) is a key issue in maintaining the sustainability of many smallholder mixed farming systems. The pivotal role played by livestock in regulating nutrient flows has generally been ignored in experimentation and crop modelling even though livestock are a tightly integrated part of the system. Smallholder farmers lack reliable support in planning their farm management practices to respond to changing environmental, demographic and market conditions.

Intensive returns of excreted nutrients from tethered livestock. Nutrients in the feed (maize stover, on the ground to the right) are transferred via the cow to the manure, ready for collection/composting.

Research highlights

Animal metabolism studies in Kenya indicated that considerable variation could be induced in manure quality by dietary manipulation. Changes in nitrogen supplementation radically altered the total amounts of nitrogen excreted and how it is distributed between faeces and urine. This may be expected to have implications for the timing of nitrogen release after the manure has been incorporated into the soil.

The dynamics of nitrogen mineralisation in soil samples may be affected by the origin of the manure, i.e. by the animal's diet. Manure produced from diets of barley straw supplemented with *Calliandra calothyrsus* and *Macrotyloma axillare* had similar nitrogen mineralisation patterns. Net cumulative nitrogen release occurred by week 16 after incorporation, following a lag phase of 12 weeks when the nitrogen was immobilised. There is evidence that nitrogen is immobilised for at least 12 weeks following applications of all manure types, suggesting that application at planting – a common local practice – may not always be most effective in promoting crop growth.

The potential significance of these observations was confirmed by pot seedling growth studies in which the highest dry matter (DM) assimilation was observed after 12 weeks in treatments where no manure had been added. Reductions in DM yields associated with the addition of manure produced from the different treatment diets ranged from 6 to 27 per cent in comparison with the un-manured control. This is consistent with the observed pattern of immobilisation of soil nitrogen.

An on-farm study on the effects of manure applications in the tea, coffee and semi-arid zones to the east of Nairobi has started to examine whether the project's experimental findings are borne out in the farmer's field. Findings from one season indicated that the nitrogen immobilisation observed in experiments, typified by the lag in growth responses, may well be occurring in the field.

Modelling activities in parallel with

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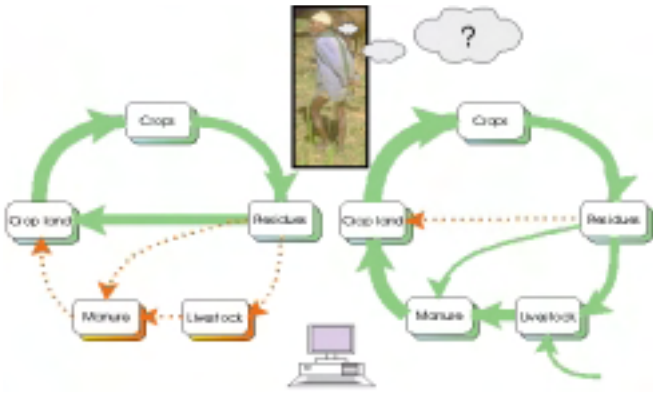
these experimental studies led to the development of the simulation model ANORAC (Allocation of Nitrogen in Organic Resources for Animals and Crops). Among other things, ANORAC allows the consequences of different strategies for using organic matter (e.g. as litters, green manures, feeds) to be evaluated.



The ANORAC model developed by the project can be used to evaluate the consequences of different organic matter management decisions.

Uptake

Livestock feed management decisions have the potential to influence nitrogen flows in soils according to which manures of different origin are incorporated. Livestock are clearly an integral and dynamic part of the mixed farming system. ANORAC is able to evaluate the trade-offs relating to nitrogen management that arise when decisions on the use of organic matter must be made. The lag phase between the application of manure to the soil and the net release of nitrogen has considerable significance for planning organic manure applications in practice. Dietary factors need to be taken into account. Application of manure at planting may not always be the most effective in promoting crop growth.

Linkages

Work initiated by the project continued in the bilateral context with a PhD student carrying out soil fertility-related work in East Africa under the aegis of a joint TSBF/CIAT (Tropical Soil Biology and Fertility Laboratory/ Centro Internacional de Agricultura Tropical) initiative.

The ANORAC model was distributed to scientists in International Agricultural Research Centres (IARCs) and National Agricultural Research Organisations (NARs). The model uses simple input variables, that can be readily available to scientists in national research programmes in developing countries, to evaluate the effects of different feeding strategies on manure quality and the release of nitrogen from incorporated manure.

Relevance to sustainable livelihoods

The ultimate sustainability of highly integrated farming systems such as the study system in Kenya is often precariously balanced. Inappropriate interventions in single system components (livestock, soil, crop) can express themselves elsewhere in the system with adverse effects on both productivity and sustainability. 'Improvements' in feed utilisation by livestock can reduce nitrogen flows to other system components which may result, in the longer term, in the depletion of soil nitrogen capital. The wider appreciation of this message by the stakeholders in intensifying systems is likely to have an important impact on preserving system sustainability.

Selected project publications

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- Delve, R.J., Tanner, J.C., Kimani, S.K., Giller, K.E., Cadisch, G. and Thorne, P.J. (1998) The effects of feed nitrogen and polyphenol levels on the fate of ingested nitrogen in steers and their implications for nitrogen cycling in mixed farming systems. p. 87. In: *BSAS/KARI Proceedings of International Conference on Food, Lands and Livelihoods: Setting Research Agendas for Animal Science, Kenya Agricultural Research Institute, Nairobi, 27–30 January 1998.* British Society of Animal Science, Edinburgh, UK.

- Thorne, P.J. (1999) Developing integrated models for application in crop/livestock systems. pp. 105–121. In: *Proceedings of a Workshop on Eco-regional Research at ILRI, Addis Ababa, 5–8 October 1998*. Thornton, P.K. and Odero, A.N. (Eds.). International Livestock Research Institute, Addis Ababa, Ethiopia.

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