Improving environmental quality

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IMPROVING ENVIRONMENTAL QUALITY

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One of the key features of research at North Wyke is the way in which scientists have become adept at working across disciplines and scales to enable more integrated approaches to research. This has many benefits and has allowed us to take a more holistic view of environmental concerns and issues than would otherwise have been the case. Here we focus on four studies which either have been, or are being developed and which illustrate this integrative approach and the innovation that this provides.

Linking diurnal patterns in photosynthesis to patterns of greenhouse gas emission

The role of plants in greenhouse gas generation has been little studied in the UK, and here, in this first example, we aim to investigate how plants may impact on emissions of the powerful greenhouse gas N_2O. By bringing together rhizosphere biology, soil microbiology and atmospheric chemistry, we aim to investigate whether there is a causal link between the observed diurnal patterns of carbon exudation from plant roots and similar diurnal patterns of N_2O emission from soil. Diurnal patterns in root exudation are thought to be driven by photosynthesis (influenced by light intensity and other environmental variables - see Figure 6.2), but the mechanisms controlling recently observed patterns of N_2O emission are not known. We therefore intend to explore linkages between the two processes with the aim of achieving further mechanistic understanding of the controlling factors affecting N_2O release.

Figure 6.1 Cornerstone of new sustainable dairy systems: goal seeking economic, environment, landscape, milk quality, welfare, soil quality and biodiversity

From a practical standpoint, these effects are also important in developing mechanistic capabilities that will allow us better to quantify the impact of this marked diurnality on the agricultural emission factor. Our studies have shown that methodologies that do not take this

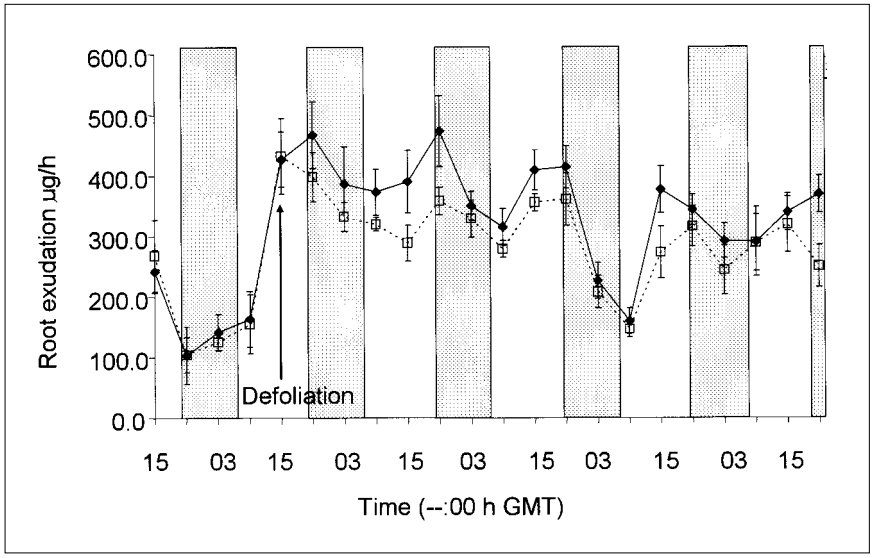

Figure 6.2 Diurnal patterns of carbon deposition by plant roots. Shaded areas = darkness. Light area = daylight

into account can under estimate N_2O emissions by 22.5% on average and thus have substantial consequences when compiling national greenhouse gas inventories and formulating mitigation strategies.

Grass roots network could cut risk of flooding

Grassland utility is becoming more multifunctional with an increasing need to consider the pivotal role of its management in river basin corridors and their role in rainfall-runoff processes that have a significant influence on flood and diffuse pollution events. North Wyke research has clearly demonstrated the impact that grassland can have on surface and drainage water quality and we have shown that there are options to manipulate soil-plant systems in farmed and semi-natural landscapes to control runoff to, and diffuse pollution of, surface water courses. What is less well known is how grassland management influences soil profile hydraulic properties and the connectivity between land surface and surface watercourses. The ability of vegetation to increase macro-porosity and to influence soil hydraulic properties has also been recently observed in collaborative work between North Wyke and the University of Plymouth. A recent research programme is making use of new varieties of grasses bred at IGER which combine *Lolium* traits for forage quality, and include *Festuca*-derived genes for improved root development, drought resistance, soil water uptake and/or water use efficiency.

To realise the benefits from breeding grasses selected for pre-determined functional traits, it is necessary to understand the implications at the field and catchment scales. In other words, we need to up-scale from the plot experiments carried out at North Wyke to the catchment scale. We propose to use a stochastic simulation model to explore the larger scale implications, for both run-off and water use, of growing grasses with different rooting traits.

We anticipate that the research will suggest ways of managing grassland so that it is more likely to act as a sink and store rainwater and less likely to shed it immediately in the form of surface run-off. Through our research we hope to make recommendations on how grassland can best be managed both to maintain productivity and to reduce run-off of surface water at critical times.

Livestock management to improve environmental quality

Linking livestock management to improved environmental quality targets has become an important priority. Research is focussed on aspects of the diets of cattle and sheep that address environmental quality - in terms of management that helps reduce nutrient losses, pathogen transfers and gaseous emissions - as well as the traditional objectives of meat and milk production. Methane is produced by enteric fermentation in ruminant digestion and is one of the most important greenhouse gases. Developing management

strategies that reduce its emission is one way to help mitigate the causes of climate change. Ammonia is another gas produced from livestock manures which contributes to environmental problems. Over the last six years we have provided new insights into sources of ammonia in livestock systems, better understood the controls over emissions and their extents and provided a suite of options for reducing the net loss to the atmosphere. As an example, diets that are higher in plants containing condensed tannins have been shown to result in more plant protein being retained by the animal and less nitrogen lost to the environment as ammonia. There may be other benefits as well, and we have become increasingly concerned with developing 'win/win' solutions on the one hand and avoiding pollution swapping on the other.

Modelling to improve environmental quality

The modelling team at North Wyke has been successful over many years in integrating different disciplines to produce models of grassland systems. The first model simulated N fluxes in grasslands (NCYCLE) while, subsequently, modelling tools and decision support systems were devised which could

Figure 6.3 and 6.4 Water run-off from grasslands

evaluate and optimise management practices (i.e. fertiliser distribution) to meet environmental and economic goals (NGAUGE). Currently, a new modelling framework (SIMSDAIRY) is being developed to identify the specification of sustainable UK dairy farms in the future. This comprises nitrogen, phosphorus and methane sub-models connected to 'score matrices' for measuring attributes of biodiversity, landscape, product quality, soil quality and animal welfare all linked together with an economic model. This model framework has been produced through a highly integrated research programme involving experts with different disciplines from IGER North Wyke, IGER Aberystwyth, ADAS, University of Reading, Exeter University, Plant Research International (The Netherlands), Velcourt and LEAF.

SIMSDAIRY simulates multiple interactions from different parts of the livestock production system. For example, polyunsaturated fatty acid (PUFA) levels in the diet are a good example of how feed characteristics may have different effects on the different sustainability controls of a dairy farm system. High levels of PUFA in the diet may have a butterfat depressing effect in the milk, which could impose penalties on farm profits. On the positive side, the ingestion of high levels of some PUFA have been reported to reduce methane emissions from the rumen, have a positive effect on fertility and increase the level of PUFAs in the milk, which could also have a positive effect on the health of consumers (i.e. milk with high levels of omega-3 fatty acids).

SIMSDAIRY aims to identify new or existing dairy systems which incorporate novel managements and components for optimal environmental and economic sustainability. The model can answer questions such as: Can we find existing farms which can both comply with the water framework directive (water quality), Kyoto protocol (greenhouse gases) and Gothenburg protocol (acid rain) and still be economically viable? Otherwise, how much money would the farm need to make ends meet? Could farmers improve their net economic margins by improving milk quality traits and hence increasing product value? Is it possible to run a profitable enterprise while simultaneously achieving sustainability targets such as: attractive landscape, healthy soil, rich biodiversity, and happy and healthy cows which produce nutritious milk?

It is important to involve the key stakeholders in evaluation of the new modelled systems as regards their practicability, likelihood of take-up by dairy farming and costs (positive and negative) to the industry. We plan to trial a range of the best of the new, more sustainable systems following discussions with stakeholders during 2006/2007.

Improving environmental quality within a productive agricultural landscape requires an understanding of how different land management practices influence a multitude of linked impacts, including water, soil and air quality, biodiversity, milk/meat product quality and, ultimately, regional economic and social impacts. In consequence, research at North Wyke has become increasingly interdisciplinary in order to address the complex issues raised by society's requirement for multi-functional landscapes. The examples above typify the inter-relationships between the IGER research teams. This interdisciplinary research is underpinned with more traditional basic research within each team to provide the mechanistic understanding of individual components of the farmed landscape. A successful future for North Wyke research and its beneficiaries relies on finding the optimal balance between this interdisciplinary and single discipline research.

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